POWER

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Self-assertion

It has always been in my observation of human nature, that a man who has any good reason to believe in himself never flourishes himself before the faces of other people in order that they may believe in him.—*David Copperfield.*

WHEN I was a young boy, I overheard my uncle make a remark about a man who had not yet learned to "carry his big bills on the inside of his roll."

I lived a good many years before I appreciated the significance of that remark.

My childish mind grasped only its literal sense and received an impression only of caution against exposure inviting theft.

But I later realized that the old gentleman was taking a sly figurative dig at the vaunting propensities of the individual in question.

We all know the man who, whatever the subject of conversation, has got something better or done something bigger or seen something more remarkable or can tell you how the affair could be better managed.

His obtrusive personality is always at the front with records of his achievements, with opinionated comments and suggestions, and positive assertions which often will not stand analysis.

It is an unfortunate characteristic which loses for its possessor the very admiration and good opinion that he apparently covets from his fellow men.

The more I see of the world and of people, the more I notice that the greater the man the less he apparently thinks of himself and the more interested he is in the thoughts and accomplishments of others.

F. R. Low

Tests of a Steam Generating Unit at a Municipal Power Plant

By J. E. WOODWELL*

THE new municipal power plant[1] (Moores Park Station) for the City of Lansing was designed to secure a high economy of operation combined with sufficient flexibility to meet the seasonable fluctuations from the larger industrial plants, among which the automotive industries predominate. The boiler plant consists of six steam generating units, in which every effort was made to co-ordinate the design of the boiler, superheater and stoker to secure the most economical performance between 100 and 200 per cent of boiler rating, and at the same time to obtain satisfactory operation with reduced efficiency at 300 per cent of rating for emergency and extraordinary peak loads of short duration.

After the boiler plant had been in operation for an extended period, one complete steam-generating unit was subjected to a thorough test conducted jointly by engineers of the equipment manufacturers, owners and the consulting engineer. The test was made under conditions that obtain in regular operation, the boiler being given a routine cleaning by the plant operators before the tests were started.

The firing was done by the regular operators, the boilers being placed under manual control instead of the automatic control regularly employed. Feed water was introduced through special test pump, piping and weigh tanks, forming a part of the permanent equipment of the station, the feed water entering the boilers at a lower temperature than that regularly obtained in the routine operation of the plant.

The coal used for the series of tests was taken from the regular source of supply, and represented a good grade of West Virginia nut and slack, averaging 13,329 B.t.u. as fired and containing an average of 3.59 per cent moisture.

Guaranteed Performance Exceeded

The guaranteed performance was based on 14,000-B.t.u. coal with one per cent of moisture, and no objection was made to the use of coal of lower grade inasmuch as the guarantees were more than fulfilled with it. The coal was weighed by an employee of the purchaser and under the supervision of the engineers, on a weighing larry calibrated by the city weighmaster. Samples of about 50 lb. per hour were taken from the stream of coal leaving the larry, and after being air dried for twenty-four hours the samples were delivered to three independent laboratories, the results of which checked very closely.

The figures for the combustible in the ash and ashpit loss are based on samples taken for a time period which allowed for a lag in the ash discharge behind the test period and are relatively correct for the different ratings up to 200 per cent.

The following series of tests were made:

Test No. 1—100 per cent rating—twenty-four hours continuous.

Test No. 2—150 per cent rating—fifteen hours continuous.

Test No. 3—200 per cent rating—three runs of ten hours each on consecutive days, added and averaged into one thirty-hour run.

Test No. 4—250 per cent rating—two runs of eight hours each, on consecutive days, added and averaged into one sixteen-hour run.

Test No. 5—300 per cent rating—three hours, capacity only.

After the main series of tests were run, an auxiliary series of four 4-hour tests were run, keeping the load constant at 181 per cent rating and varying the carbon dioxide to 9, 10, 12 and 14 per cent. The purpose of this series was to determine by test the effect of carbon dioxide on the pressure drops, exit-gas temperatures, calculated efficiency and superheat.

The complete results of these tests are shown graphically and in tabular form, from which some of the most important conclusions may be summarized as follows:

Summary of Test Results

The efficiency ranged from 81.3 at 100 per cent rating to 78.9 at 200 per cent rating, which was only lowered to 75 per cent at the 300 per cent rating, thereby exceeding the guarantee by a substantial margin, as shown on Curve No. 1.

Curve No. 21 shows the relation between the stack loss and the carbon dioxide in the exit gases determined by calculating items in the heat balance for each of the four different values of the CO_2 in the exit gases.

On the assumption that the same ashpit and radiation losses existed for each of the four auxiliary runs as was found in the main series of tests, the relation between CO_2 in the exit gases and the over-all efficiency of the unit was calculated as shown in Curve No. 21. The importance of securing high CO_2 close to the point where CO was formed is conclusively shown by this curve.

This conclusion is also well borne out by the routine operation of the plant, which fully substantiates the test efficiencies sustained over monthly periods, the average combined boiler and stoker efficiency for the month of June being 79.8 per cent at an average load of 129 per cent.

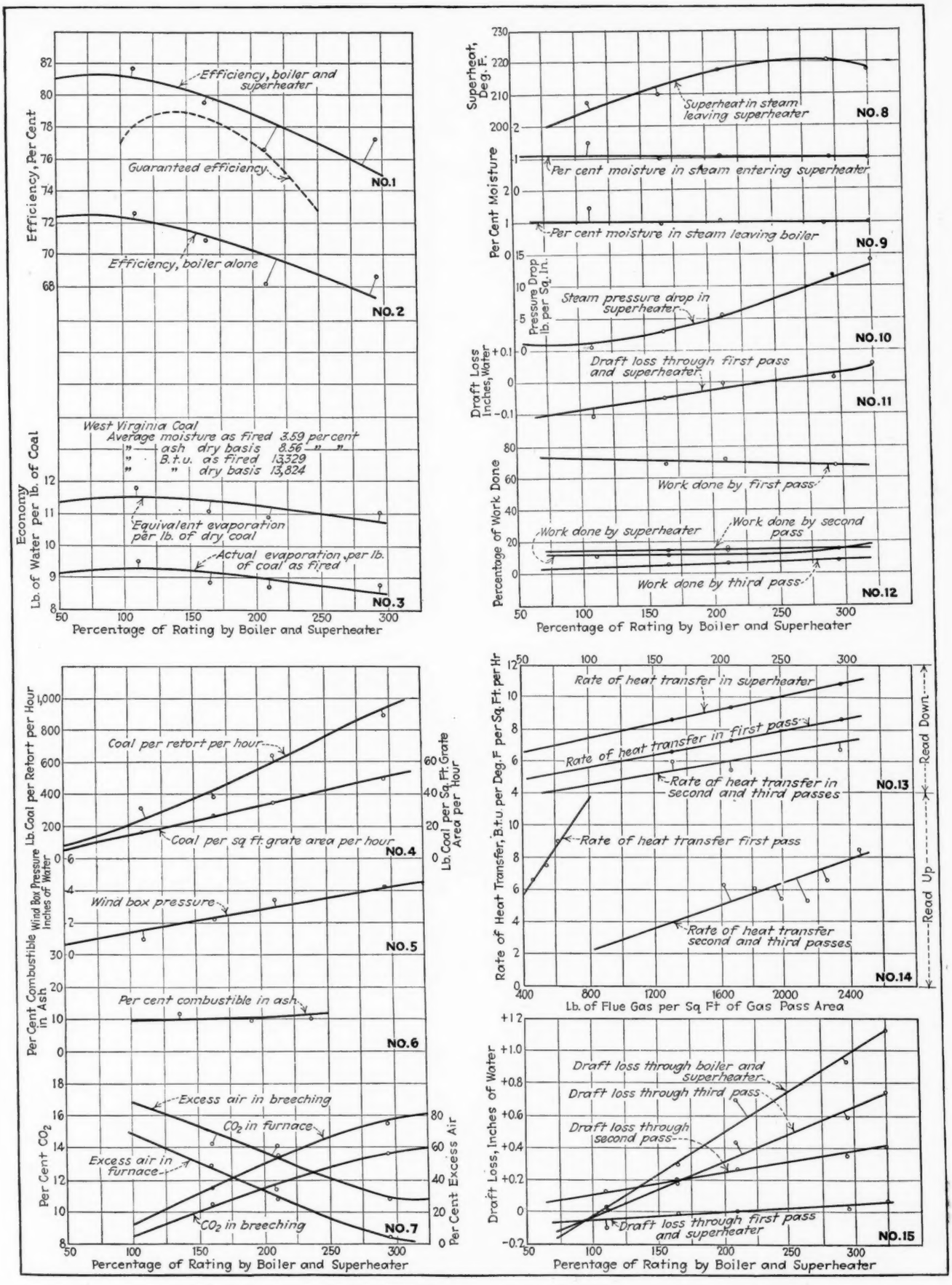
The performance of the stoker at different ratings is shown by the curves Nos. 4, 5, 6 and 7. The CO_2 in the flue gases increased with the rating, being practically constant at 11.5 per cent from 100 to 150 per cent of rating; 13 at 200 and 15.5 at 300 per cent of rating. These curves also show the percentages of CO_2 in the boiler breeching, which are somewhat lower and show the effect of air in filtration and perhaps some stratification.

The combustible in the ash increased with the rating, being 9.5 per cent at 100 per cent rating and 12.5 at 200 per cent rating.

The windbox pressure varies nearly as a straight line from 1.3 in. of water at 100 per cent to 4.4 in. of water

*Consulting Engineer, 501 Fifth Avenue, New York City.

[1]See June 19, 1923, issue.


Efficiency, Per Cent
Efficiency, boiler and superheater
Guaranteed efficiency
NO.1
Efficiency, boiler alone
NO.2
West Virginia Coal
Average moisture as fired 3.59 per cent
" ash dry basis 8.56 " "
" B.t.u. as fired 13329
" " dry basis 13,824
Economy
Lb. of Water per lb. of Coal
Equivalent evaporation per lb. of dry coal
Actual evaporation per lb. of coal as fired
NO.3
Percentage of Rating by Boiler and Superheater
Superheat, Deg. F.
Superheat in steam leaving superheater
NO.8
Per Cent Moisture
Per cent moisture in steam entering superheater
Per cent moisture in steam leaving boiler
NO.9
Pressure Drop lb. per Sq. In.
Steam pressure drop in superheater
NO.10
Draft Loss Inches, Water
Draft loss through first pass and superheater
NO.11
Percentage of Work Done
Work done by first pass
Work done by superheater
Work done by second pass
Work done by third pass
NO.12
Percentage of Rating by Boiler and Superheater
Lb. Coal per Retort per Hour
Coal per retort per hour
Coal per sq ft. grate area per hour
Lb. Coal per Sq. Ft. Grate Area per Hour
NO.4
Wind Box Pressure Inches of Water
Wind box pressure
NO.5
Per Cent Combustible in Ash
Per cent combustible in ash
NO.6
Per Cent CO_2
Excess air in breeching
CO_2 in furnace
Excess air in furnace
CO_2 in breeching
Per Cent Excess Air
NO.7
Percentage of Rating by Boiler and Superheater
Rate of Heat Transfer, B.t.u. per Deg. F. per Sq. Ft. per Hr
Rate of heat transfer in superheater
Rate of heat transfer in first pass
Rate of heat transfer in second and third passes
NO.13
Rate of heat transfer first pass
Rate of heat transfer second and third passes
NO.14
Read Down
Read Up
Lb. of Flue Gas per Sq. Ft. of Gas Pass Area
Draft Loss, Inches of Water
Draft loss through boiler and superheater
Draft loss through third pass
Draft loss through second pass
Draft loss through first pass and superheater
NO.15
Perentage of Rating by Boiler and Superheater

Results of tests at various ratings from 100 to 350 per cent, shown graphically

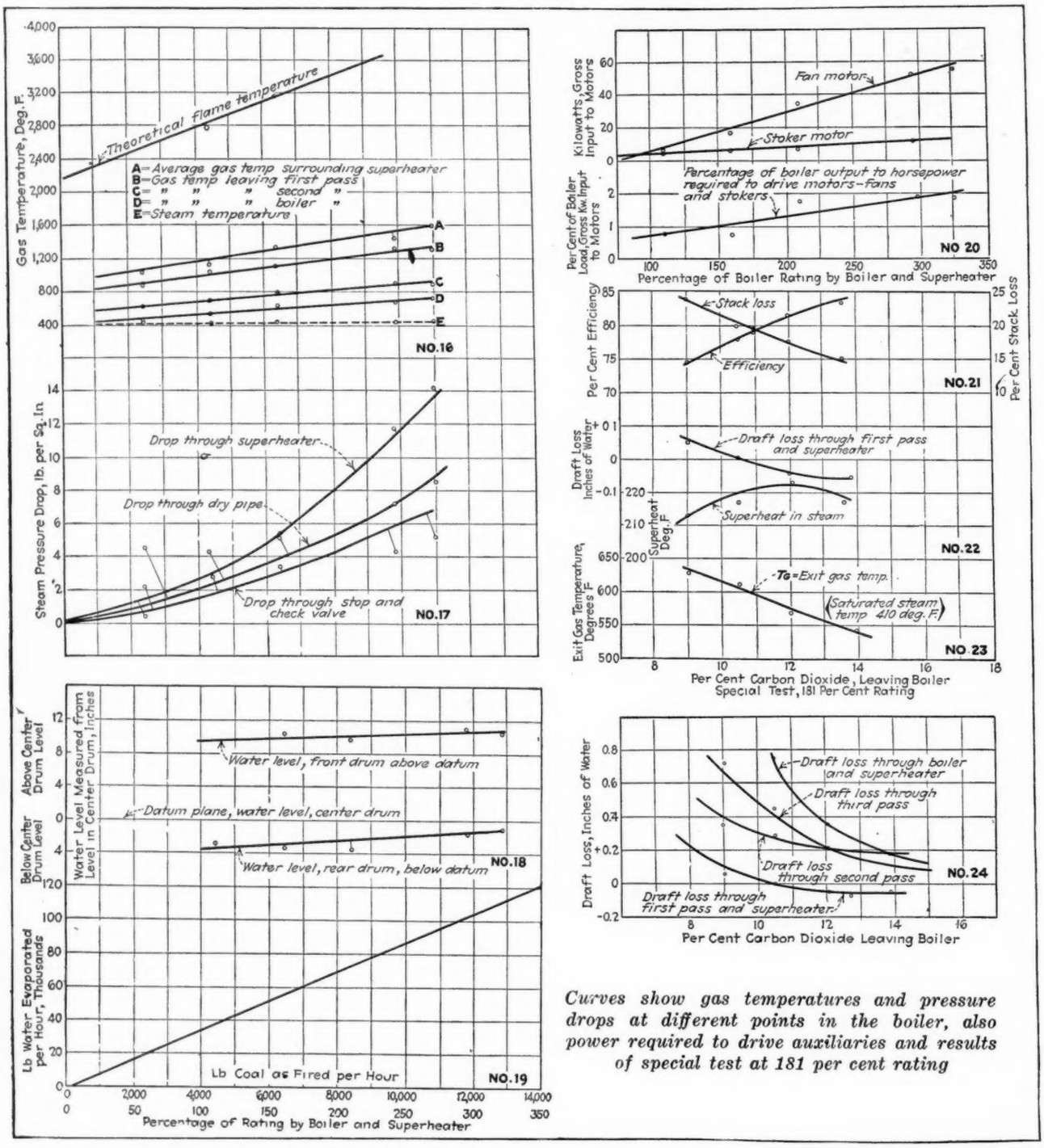
at 325 per cent rating. The performance of the superheater is illustrated by curve No. 8, which shows that for the entire range of the tests (108 to 323 per cent rating) the maximum variation in the superheat was only about 14 deg. F. The maximum superheat occurs at 275 per cent rating.

The superheater was designed for 200 deg. of superheat at 200 per cent rating. The guaranteed superheat was exceeded at all loads from 100 to 350 per cent rating.

The superheater had the advantage of working with dry and extremely constant quality steam. The moisture fraction of the steam at all loads between 100 and 350 per cent rating was between 1.0 and 1.1 per cent.

As a measure of the effect of the superheater on draft loss the draft loss through the first pass and superheater was plotted. Owing to the stack effect in the vertical first pass this factor is small, amounting to about minus 0.9 in. of water at 100 per cent rating and increasing as a straight line to about plus 0.5 in. at 350 per cent rating. This factor will form an effective basis to compare the draft loss with a similar unit equipped with radiant-heat superheater.

The Curve No. 17 shows the steam pressure drop through different parts of the unit. To obtain these data, calibrated pressure gages were installed, one on the boiler drum, two on each U-bend leaving the boiler, two on each end of the superheater outlet header and


Gas Temperature, Deg. F.
Theoretical flame temperature
A=Average gas temp surrounding superheater
B=Gas temp leaving first pass
C=" " " second "
D=" " " boiler "
E=Steam temperature
NO.16
Steam Pressure Drop, lb. per Sq. In.
Drop through superheater
Drop through dry pipe
Drop through stop and check valve
NO.17
Water Level Measured from Level in Center Drum, Inches
Above Center Drum Level
Below Center Drum Level
Water level, front drum above datum
Datum plane, water level, center drum
Water level, rear drum, below datum
NO.18
Lb Water Evaporated per Hour, Thousands
Lb Coal as Fired per Hour
NO.19
Percentage of Rating by Boiler and Superheater
Kilowatts, Gross Input to Motors
Fan motor
Stoker motor
Per Cent of Boiler Load, Gross kw Input to Motors
Percentage of boiler output to horsepower required to drive motors—fans and stokers
NO 20
Percentage of Boiler Rating by Boiler and Superheater
Per Cent Efficiency
Stack loss
Efficiency
NO.21
Per Cent Stack Loss
Draft Loss Inches of Water
Draft loss through first pass and superheater
Superheat Deg. F.
Superheat in steam
NO.22
Exit Gas Temperature, Degrees F.
Te=Exit gas temp.
Saturated steam temp 410 deg. F.
NO.23
Per Cent Carbon Dioxide, Leaving Boiler
Special Test, 181 Per Cent Rating
Draft Loss, Inches of Water
Draft loss through boiler and superheater
Draft loss through third pass
Draft loss through second pass
Draft loss through first pass and superheater
NO.24
Per Cent Carbon Dioxide Leaving Boiler

Curves show gas temperatures and pressure drops at different points in the boiler, also power required to drive auxiliaries and results of special test at 181 per cent rating

two on each main steam line outside the automatic stop and check valve.

The steam-pressure drop through the superheater is greatest, increasing with the load from a negligible amount at low rating to about 11.5 lb. per sq.in. at 300 per cent rating. This drop is considered conservative for this type of double- and triple-loop superheater.

The steam-pressure drop through the dry pipe is high, but not excessively so. It varies from a negligible amount at low rating to about 7.5 lb. per sq.in. at 300 per cent rating. The advantage of some constriction in the dry pipe is shown in the moisture fraction curve.

To determine the water level in the three drums for the boiler, special gage glasses were installed and readings taken every fifteen minutes throughout the tests. The results of the water-level readings are shown on Curve No. 18. The constant water-level conditions are due to ample circulators in both steam and water space and to the special design, in which only part of the tubes in the front pass discharge into the front drum, the remainder being bent back to discharge into the enlarged center drum.

Curve No. 16 shows the temperature of gases in different parts of the boiler. The theoretical flame temperature is the temperature of the furnace gas before any heat is given up by radiation to the boiler tubes or furnace walls. This figure is higher than the reading of an optical pyrometer or thermocouple in the furnace, but is the proper figure to use in calculating temperature drop, mean temperature difference or rate of heat transfer in the first pass of the boiler. The gas temperature (*A*) surrounding the superheater (*B*) leaving the first pass and (*C*) leaving the second pass were calculated from the readings of thermocouples corrected for radiation to the surrounding cool boiler tubes. Curve D shows the temperature of exit gases leaving the boiler. Each point is the average of the reading from four thermocouples equally spaced across the breaching, outside of and close to the damper, in the full stream of gas flow. The curve is more nearly a straight line than the theoretical exit-gas temperature curve, owing to the fact that the CO_2 varied as the rating was increased.

At 100 per cent rating and approximately 8.4 per cent CO_2 in the breeching the exit-gas temperature was 460 deg., or 50 deg. above steam temperature. At 200 per cent rating and 11.1 per cent CO_2, the exit-gas temperature was 555 deg., or 140 deg. above steam temperature. At 325 per cent rating and 14.0 per cent CO_2, the exit-gas temperature was 690 deg. or 275 deg. above steam temperature.

On Curve No. 12 the percentage of the total work of the unit that is done in each pass and done in the superheater is shown; 73 per cent of the work done by the unit or 82 per cent of the work done by the boiler at 100 per cent rating is done in the first pass. At 325 per cent rating these figures become 68 and 80 per cent respectively.

About 13 per cent of the work done by the unit, or 14.5 per cent of the work done by the boiler at 100 per cent rating, is done in the second pass. The percentage of work done by the second pass remains nearly constant at all loads. The work done in the third pass is very small, being only about 3.5 per cent of the work done by the unit or 4 per cent of the work done by the boiler. As the load increases, a larger percentage of work is thrown into the last pass; at 325 per cent rating the figures become 8 and 9 per cent respectively.

A straight-line curve closely represents the relation between the rate of heat transfer in B.t.u. per square foot per degree mean temperature difference per hour and gas flow in pounds per square foot of gas pass area per hour. The rate of heat transfer in the first pass is high owing to the fact that heat is transferred by radiation as well as convection. The rate varies as a straight line from 5.7 at 400 lb. per sq.ft. to 11.3 at 800 lb. per sq.ft. Heat is transferred in the second and third passes by convection alone, and the rate varies as a straight line from 5.0 at 1,600 lb. per sq.ft. to 8.1 at 2,600 lb. per sq.ft. The power consumed by the draft fan, stoker motor, etc., was less than 2 per cent at the highest rating.

Exit gases are taken from the unit by radial-brick stack mounted on the roof trusses and having an effective height above the grates of 250 ft. and an internal diameter of 13 ft. at the top.

The details of the equipment are given in the table.

DATA AND RESULTS OF EVAPORATION TESTS

Boiler type	Heine V-type-bent tube—3 pass.
Boiler heating surface, sq. ft.	15,000.
Boiler steam drums	Three; one 48 in. dia., two 42 in. dia., all 31 ft. 9 in.
Boiler mud drum	One, 48 in. dia., 28 ft. 6 in. long, 880 long tubes and 330 circulators 3½ in. dia.
Superheater type and location	Elesco—bare tube—double loop—located between boiler tubes—first pass.—1700 sq.ft.
Boiler heating surface per sq. ft. of superheating surface, sq. ft.	8.82
Superheating surface per sq. ft. of grate area, sq. ft.	5.6
Furnace, volume, cu. ft.	8580
Furnace volume per sq. ft. of boiler heating surface, cu. ft.	0.572
Furnace volume per sq. ft. of grate area, cu. ft.	28
Furnace volume per stoker retort, cu. ft.	536.2
Distribution of boiler heating surface	First pass 6680 sq. ft.—second pass 4410 sq. ft.—third pass 3910 sq. ft.
Boiler passes, free area of opening.	First pass 275 sq. ft.—second pass 82.5 sq. ft.—third pass 82.5 sq. ft.
Stoker type	Riley underfeed.
Number of retorts	16
Stoker drive	Silent chain to 25 hp. variable speed motor.
Clinker grinder type	Single roll.
Clinker grinder drive	From stoker motor drive via jackshaft.
Projected grate area, sq. ft.	302.28
Ratio water heating surface to grate area	48.8
Forced draft fan, number, type, capacity	One Sturtevant radial flow, double inlet—65,000 cu. ft. per min.
Fan capacity per sq. ft. of grate area, cu. ft.	215
Fan capacity per cu. ft. of furnace volume, cu. ft.	7.6

Rating, Duration, Etc.					
Test No.	1	2	3	4	5
Rating developed by boiler and superheater, per cent	108	161	209	294	323
Duration of tests, hours	24	15	30	16	3
Coal					
Kind of Coal	West Virginia				
Moisture in coal as fired, per cent	3.23	3.67	3.81	3.64	....
Heating value of 1 lb. of coal, B.t.u. as fired	13,614	13,079	13,325	13,297	....
—dry basis	14,068	13,577	13,851	13,799	....
Proximate analysis of dry coal, per cent:					
Volatile per cent	31.76	34.21	32.27	35.31	....
Fixed carbon, per cent	60.43	56.02	58.72	57.03	....
Ash, per cent	7.81	9.77	9.01	7.66	....
	100.00	100.00	100.00	100.00	....
Sulphur (separately determined)	0.83	1.25	1.17	1.97	....
Ultimate analysis of dry coal, per cent:					
Carbon, per cent	78.40	75.61	77.00	76.61	....
Hydrogen, per cent	5.04	4.94	4.98	5.05	....
Sulphur, per cent	0.76	1.25	1.17	1.97	....
Oxygen, per cent	6.96	7.42	6.82	7.68	....
Nitrogen, per cent	1.03	1.01	1.02	1.03	....
Ash, per cent	7.81	9.77	9.01	6.66	....
	100.00	100.00	100.00	100.00	....
Ash and Soot					
Combustible in ash and refuse, per cent	11.27	8.99	10.09	20.75	....
Ash and refuse, per lb. of dry coal, lb.	8.81	10.74	10.03	9.67	....
Combustible in soot and fly ash, per cent	28.67	36.52	41.49	73.18	....

DATA AND RESULTS OF EVAPORATION TESTS (Concluded)

Feed Water Temperature					
Temperature of feed water entering boiler, deg. F.	177.8	173.4	177.4	176.0	183.5
Steam Pressures and Pressure Drops					
Steam pressure in boiler drum, lb. gage	266.0	265.8	271.0	279.2	277.7
Steam pressure leaving boiler drum average, lb. gage	261.5	261.5	265.9	271.8	269.2
Steam pressure leaving superheater, average lb. gage	261.1	258.7	260.5	260.1	255.1
Steam pressure leaving stop and check valve, average lb. gage	258.9	255.9	257.2	255.7	250.0
Steam pressure drop through dry pipe, average lb. gage	4.5	4.3	5.1	7.4	8.5
Steam pressure drop through superheater, average lb. gage	0.4	2.8	5.4	11.7	14.1
Steam pressure drop through stop and check valve, average, lb. gage	2.2	2.8	3.3	4.4	5.1
Steam, Temperature, Superheat, Etc.					
Temperature of steam leaving superheater, average, deg. F.	616.3	618.4	627.1	631.1	624.0
Superheat in steam leaving superheater, average, deg. F.	206.6	209.5	217.5	221.8	216.4
Factors of Evaporation					
Factor of evaporation for boiler	1.0769	1.0854	1.0811	1.0832	1.0754
Factor of evporation for boiler and superheater	1.2099	1.2160	1.2160	1.2196	1.2086
Air and Flue Gas Pressures, Drafts and Draft Losses					
Pressure in air chamber underneath stoker grate, in water	1.027	2.165	3.449	4.112	4.334
Draft in furnace, in water	0.035	0.051	0.035	0.111	—0.026
Draft leaving first pass and superheater, in water	—0.075	—0.009	0.026	0.117	0.069
Draft leaving second pass, in water	0.043	0.117	0.289	0.448	0.455
Draft leaving third pass, in water	0.047	0.350	0.721	1.043	1.167
Available draft in breeching outside damper, in water	....	....	1.094	1.087	1.218
Draft loss through grate and fuel bed, in water	1.062	2.216	3.484	4.223	4.360
Draft loss through first pass and superheater, in water	—0.110	—0.060	—0.009	0.006	0.043
Draft loss through second pass, in water	0.118	0.186	0.263	0.331	0.386
Draft loss through third pass, in water	0.004	0.173	0.432	0.595	0.712
Draft loss through boiler and superheater, in water	0.012	0.299	0.686	0.932	1.141
Available draft not used, in water	....	....	0.373	0.044	0.051
Air and Flue Gas Temperatures, Temperatures Drops, Etc.					
Temperature of air entering fan, deg. F.					
Dry bulb, deg. F.	61.5	63.2	60.8	69.4	60.8
Wet bulb, deg. F.	54.0	52.0	48.4	60.0	54.2
Moisture in air entering fan per 1000 lb. of dry air, lb.	7.3	5.9	4.4	9.0	7.5
Furnace temperature calculated from furnace gas analysis, deg. F.	....	2787	3153	3505	....
Gas temperature surrounding superheater, average, deg. F.	1010	1188	1257	1425	1595
Gas temperature leaving first pass, deg. F.	962	1014	1114	1305	1305
Gas temperature leaving second pass, deg. F.	605	669	774	897	874
Gas temperature leaving third pass, deg. F.	563	608	672	712	756
Gas temperature leaving boiler, deg. F.	452	531	607	652	694
Gas temperature drop through first pass and superheater, deg. F.	....	1773	2039	2200	....
Gas temperature drop through second pass, deg. F.	357	345	340	408	431
Gas temperature drop through third pass, deg. F.	153	138	167	245	180
Gas temperature drop through boiler and superheater, deg. F.	....	2256	2546	2853	....
Hourly Rates					
Coal as fired per sq. ft. of grate area per hour, lb.	16.18	25.8	34.0	47.5	....
Dry coal per sq. ft. of grate area per hour, lb.	15.66	24.8	32.7	45.8	....
Coal as fired per cu. ft. of combustion space per hour, lb.	0.57	0.91	1.20	1.67	....
Dry coal per cu. ft. of combustion space per hour, lb.	0.055	.088	1.15	1.61	....
Equivalent evaporation by boiler per sq. ft. of boiler heating surface per hour, lb.	3.32	4.97	6.40	9.00	9.92
Equivalent evaporation by boiler and superheater per sq. ft. of boiler heating surface per hour, lb.	3.74	5.57	7.19	10.13	11.15
Equivalent evaporation by boiler and superheater per sq. ft. of total heating surface per hour, lb.	3.35	5.06	6.46	9.10	10.02
Capacity					
Percentage of rated boiler capacity developed by boiler	96	144	185	261	288
Percentage of rated boiler capacity developed by boiler and superheater	108	161	209	294	323

Economy					
Water evaporated per lb. of coal as fired, lb.	9.45	8.81	8.65	8.68	....
Water evaporated per lb. of dry coal, lb.	9.77	9.15	8.99	9.01	....
Equivalent evaporation by boiler and superheater per lb. of coal as fired, lb.	11.44	10.71	10.52	10.59	....
Equivalent evaporation by boiler and superheater per lb. of dry coal, lb.	11.82	11.12	10.93	10.99	....
Efficiency					
Efficiency of boiler, furnace and grate, per cent	72.60	70.97	68.08	68.62	....
Efficiency of boiler, superheater furnace and grate, per cent	81.56	79.50	76.58	77.27	....
Firing Data					
Power required to drive stoker, kw.	4.16	6.22	7.15	10.65	12.03
Power required to drive forced draft fan, kw.	5.95	16.95	35.84	51.9	55.7
Analysis of dry flue gas in furnace, per cent:					
Carbon dioxide	....	11.52	13.45	15.37	16.07
Oxygen	....	6.90	4.86	1.24	0.23
Carbon monoxide	....	0.06	0.04	1.03	0.47
Nitrogen	....	81.52	81.65	82.36	83.23
	100.00	100.00	100.00	100.00	100.00
Excess air in flue gas leaving furnace, per cent	....	47.7	28.7	3.5	0.0
Weight of dry flue gas leaving furnace per lb. of dry coal, lb.	....	16.32	14.37	11.74	....
Total weight of flue gas leaving furnace per lb. of dry coal, lb.	....	16.90	14.92	12.33	....
Analysis of dry flue gas leaving boiler, per cent:					
Carbon dioxide	12.51	10.40	11.04	13.59	13.94
Oxygen	....	8.24	7.99	4.70	4.60
Carbon monoxide	....	0.03	0.03	0.08	0.00
Nitrogen	....	81.33	80.94	81.63	81.46
	100.00	100.00	100.00	100.00	100.00
Excess air in flue gas leaving boiler per cent	....	62.1	60.6	28.0	27.2
Air leakage through boiler setting, per cent	....	9.8	24.8	23.7	27.2
Weight of dry flue gas leaving boiler per lb. of dry coal, lb.	....	18.04	17.36	14.01	....
Total weight of flue gas leaving boiler per lb. of dry coal, lb.	....	18.63	17.92	14.63	....
Distribution of Work					
Percentage of work done by superheater	10.99	10.8	11.1	11.1	11.02
Percentage of work dene by first pass of boiler	....	70.0	71.7	68.1	....
Percentage of work done by second pass of boiler	....	14.0	11.8	13.1	....
Percentage of work done by third pass of boiler	....	5.2	5.4	7.7	....
Rate of Heat Transfer					
Rate of heat transfer in superheater per sq. ft. per hour per degree mean temperature difference, B.t.u.	....	8.53	9.31	10.67	....
Rate of heat transfer in first pass of boiler, per sq. ft. per hour per degree mean temperature difference, B.t.u.	....	6.56	7.52	8.50	....
Rate of heat transfer in second pass of boiler per sq. ft. per hour per degree mean temperature difference, B.t.u.	....	6.34	5.46	6.59	....
Rate of heat transfer in third pass of boiler per sq. ft. per hour per degree mean temperature difference, B.t.u.	....	5.98	5.38	8.42	....

Heat Balance	B.t.u.	Percent	B.t.u.	Percent	B.t.u.	Percent
Heat absorbed by boiler	9635	70.96	9433	68.10	9469	68.62
Heat absorbed by superheater	1159	8.54	1177	8.50	1192	8.64
Efficiency	10794	79.50	10610	76.60	10661	77.26
Loss due to combustible in ash and refuse	142	1.05	150	1.08	193	1.40
Ash pit loss	142	1.05	150	1.08	193	1.40
Loss due to combustible in soot and fly ash	....	....	....	....	....	....
Soot hopper loss	....	....	....	....	....	....
Loss due to heat in theoretical dry flue gas	1254	9.24	1474	10.63	1588	11.50
Loss due to heat in moisture accompanying theoretical air	14	0.10	12	0.09	27	0.20
Loss due to steam from combustion of hydrogen	563	4.15	586	4.23	600	4.35
Loss due to steam from moisture in coal	48	0.35	52	0.38	50	0.36
Loss due to moist excess air up to 40 per cent introduced through furnace	491	3.62	292	2.11	48	0.35
Loss due to moist excess air in excess of 40 per cent introduced through furnace	95	0.70	0	0.00	0	0.00
Loss due to moist excess air leakage through boiler setting	177	1.30	325	2.35	337	2.44
Loss due to carbon monoxide	22	0.16	21	0.15	44	0.32
Stack loss	2664	19.62	2762	19.94	2694	19.52
Radiation and unaccounted for	23	0.17	331	2.38	251	1.82
Heating value of 1 lb. of dry coal	13577	100.00	13851	100.00	13799	100.00

Locating Faults in Synchronous Motors

By A. A. FREDERICKS

DIFFICULTIES that may be experienced in the operation of synchronous motors are discussed and the causes of heating in bearings and windings explained in detail

A SYNCHRONOUS motor is an alternating-current generator with slight modifications in design, operated as a motor. Like the alternator it must have its field coils, Fig. 1, excited with direct current. In this respect the synchronous motor differs from other types of alternating-current motors, so that when diagnosing troubles in this class of equipment, not only the motor and starter must be considered, but also the source of direct current for exciting the field coils should be given attention. If the exciting current is supplied from a direct-current power plant, the only consideration, so far as the excitation source is concerned, is to know that power is available at the field switch. Where the motor has an individual exciter driven from its shaft, as in Fig. 4, then any of the troubles that may occur in a direct-current generator are applicable to the exciter. However, this statement should not be construed to mean that the exciter on a synchronous motor is a prolific source of trouble. With ordinary care these machines operate with a high degree of reliability.

Troubles on synchronous motors, as for any other type of motor, may be divided into mechanical and electrical. The mechanical troubles are heating of bearings, vibration, motor out of level, bearings worn so as to let rotor out of center of stator bore, overloads, and failure to start. Some of these may also be classed as electrical troubles. The electrical troubles may be: failure to start, start but fail to come up to synchronous speed, heating, hunting, noise, and vibration. There are other troubles, but they can be classed under the foregoing and will be taken up under some of the headings.

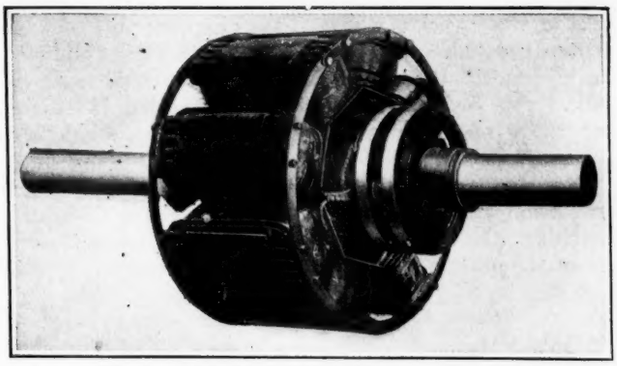


Fig. 1—Rotor of synchronous motor

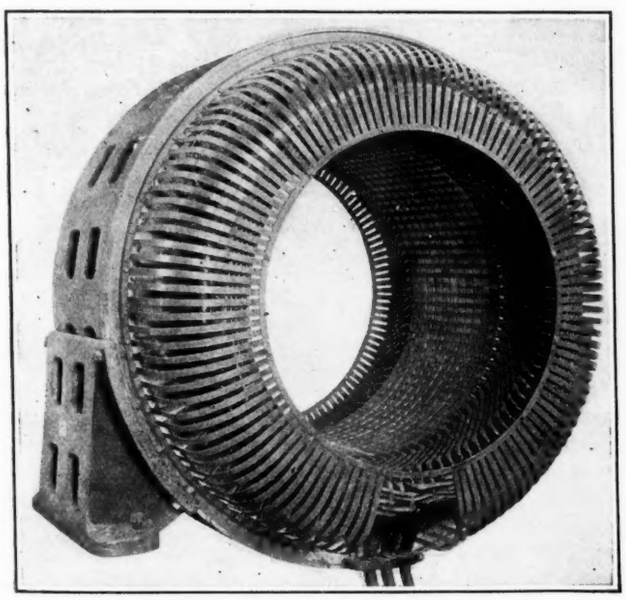


Fig. 2—Stator of synchronous motor has distributed winding

Bearing troubles are common to all types of machines. However, if a motor is properly lined up to its load, is kept properly lubricated with a good grade of clean oil and, where a belt drive is used, proper tension is maintained in the belt, little trouble should be experienced with heating or wearing of bearings.

Common Sources of Bearing Troubles

Two common sources of bearing troubles are bent oil rings and dirt in the oil. If the rings are not perfectly round, they are liable to fail to revolve with the shaft and before this may be discovered the shaft has started to wear the bearing, thus letting the rotor out of the center of the stator bore. It is always advisable, after a motor is first started, to watch the oil rings closely for the first few days of operation to see that they do not develop any tendency to stick. After this the oil rings should be inspected at the regular periodical inspections. It should be impossible to make a properly operating ring stick. Even when intentionally stopped the ring should immediately start to revolve with the shaft when released. Dirt in the lubricating oil may get between the oil ring and shaft and prevent the former from revolving, and it may clog up the passages in the bearing housings and prevent the oil from returning to the well after passing through the bearing. Some bearings are so designed that the passages *A*, leading from the end of the bearing into the oil well are small, as in Fig. 3. If there is any dirt in the oil or the motor is operating in a dirty and dusty location, these passages should be inspected frequently. If they become obstructed, instead of the oil flowing back into the well, it will flow out over the end of the bearing housing. It is surprising how quickly a bearing may be emptied in this way.

Another source of bearing trouble, particularly on belt drives, is that the motor is not level on its base. This tends to throw the weight of the rotor between the one shoulder on the shaft and the inside end of the bearing on the low side of the machine. This load is carried on a comparatively small area and may be sufficient to cause serious heating of the bearing. The rotor going over to the low side tends to pull it out of line with the stator core and disturbs the magnetic balance. That is, gravity tends to pull the rotor out

of the stator bore, whereas the magnet pull tends to center the pole faces on the stator core. Conditions have been obtained where the action between these two forces was such as to set up an objectionable endwise oscillation of the rotor, which caused the shoulders on the shaft to pound the inside ends of the bearings.

The rotor should be so located that there is a free oscillation between the collars on the shaft and the bearings. If the rotor is placed off the magnetic center of the stator, a heavy thrust will be caused between

Fig. 3—Cross-section of motor bearing

one collar on the shaft and bearing, which may result in excessive heating.

Where the motor is used on a belt drive, there is always the danger of excessive tension in the belt, causing heating of the bearings. The belt should be maintained only tight enough to drive the load without unnecessary slippage. On direct drives through a rigid coupling, the motor may be out of line with its load sufficiently to cause binding of the shaft in the bearings to an extent that will cause heating. Such a condition should also cause vibration.

Out of balance of the rotating member will also cause vibration. Where a pulley is used on the motor shaft, the rotor may be in balance, but the pulley sufficiently out of balance to cause vibration. Therefore, should it become necessary to test such a rotor for balance, it should be tested with the pulley off the shaft and, if found in balance, checked with the pulley in place. The pulley may be properly balanced, but if its bore is too large for the shaft, the key will throw it over to one side sufficiently to cause unbalancing and vibration.

Causes of Bearings Heating

It is necessary that the rotor be kept centered in the stator bore if excessive loading of the bearing is to be prevented and quiet operation maintained. In some motors, if the rotor is not centered in the stator bore, they have a tendency to issue a loud growling sound. They may also make a similar sound when not level on their foundation or if the rotor is set on the shaft so that the bearing collars prevent it from lining up with the stator core.

Another cause of heating of the bearings is where the motor is running at an excessive temperature, due to overload or other causes. However, this is not so likely to be the case as in direct-current motors, where the overloaded part is directly on the shaft. Except in small high-speed machines the field poles of synchronous motors are mounted on the shaft and are not likely to be overloaded except when an excessive voltage is applied to them.

With the larger-size motors the rotor frequently is mounted directly on the shaft of the machine that the motor is driving, as in Fig. 4, in which case the motor has no bearings other than those of the driven machine. This is also the arrangement used on some small-sized slow-speed drives. With this type of drive contributory causes that may be due to the driven machine must also be considered when trouble is experienced with bearings heating.

Heating of Motor Windings

One of the most common causes of heating of synchronous motor windings is excessive stator current due to improper field adjustment when the motor is driving nearly its normal rated load. Unlike any other type of alternating-current motor the current taken by a synchronous motor required for driving a given mechanical load can be varied over wide ranges by changing the value of the field current, which in turn changes the power factor of the motor. For example, a motor driving 70 per cent normal rated mechanical load will take approximately 70 per cent full-load current at unity power factor. By increasing the field strength to give the motor a leading power factor of about 0.70, the motor will take approximately full-load current. At 90 per cent load the field current would have to be adjusted to give the motor a power factor of about 0.90 or the machine will be overloaded if it is less than this value. If the motor were carrying 90 per cent load and the power factor were adjusted to 0.70, then the motor would be about 30 per cent overloaded and serious heating would probably result. For this reason a synchronous motor should be equipped with an ammeter in the alternating-current line to guide the operator in adjusting the field current to maintain the motor current within full-load limits unless the motor is actually overloaded mechanically, in which case the full-load current should be adjusted to the minimum value. This value is obtained with unity power factor. Of course, if the motor is overloaded mechanically, it may be expected to overheat, irrespective of how the field current may be adjusted, but adjustment to unity power factor will give the minimum current in the stator windings.

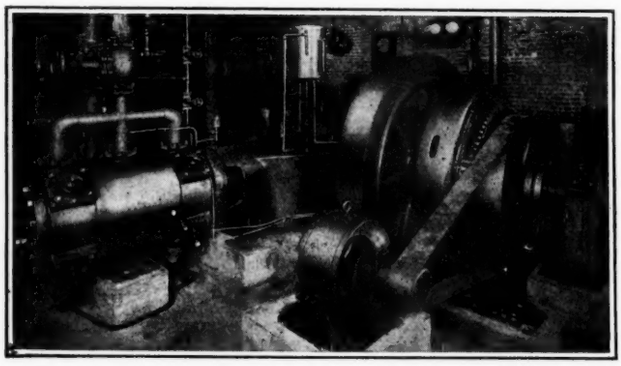


Fig. 4—Synchronous motor mounted directly on compressor shaft; exciter belt driven

Synchronous motors may be divided into two classes —those for unity-power-factor operation and those that may be used for power-factor correction in addition to driving mechanical load. Unity-power-factor motors usually have their field windings designed for a current

capacity sufficient to give unity power factor at full mechanical load. Such a motor is not intended to have the field current adjusted to cause the motor to take full-load current at leading power factor and less than rated mechanical load. If this is attempted, the field coils are liable to overheat and destroy the insulation. If it is intended to use synchronous motors to drive mechanical loads and, at the same time, correct power factor, this should be specified when purchasing the motors, so that the manufacturer can supply machines with sufficient field-coil capacity for the service.

Other causes for overheating of synchronous motors are: Open field circuit, some of field coils with wrong polarity or short-circuited, open-circuit in one phase caused by an open in one of the windings or open line wire, incorrect line voltage or unequal voltages on the different phases, grounds in the windings, short-circuits in the stator windings, incorrect connections, and rotor out of center of stator bore.

If the field-circuit opens or the voltage on the exciter circuit fails while the motor is in operation, it will pull out of step and stop, if carrying near its rated load. If lightly loaded, it will continue to run as an induction motor, but will take a greatly increased current from the line at a low lagging power factor. This current will generally exceed the rated full-load value of the motor and cause it to heat. Under such conditions of operation the motor will issue a loud growling sound and will probably be unstable in its operation. Failure of the exciting current may be due to an open-circuit in the field winding of the motor, the brushes making poor contact with the slip rings, open-circuit in the external wiring or field rheostat or failure of the exciter voltage.

Wrong Polarity of Field Coils

Wrong polarity of field coils is something that might be found in a new motor or one that had been repaired. This fault would be located as in a direct-current machine by exciting the coils with direct current and then testing the polarity with a compass or piece of iron. Short-circuits or ground in field coils would also be located as for direct-current machines, and are faults that are liable to develop unless the field coils are kept connected to the discharge resistance until after the motor has started. During the starting period the field coils act as the secondary of a transformer and have a voltage induced in them. With the field coils open-circuited during the starting period, this voltage may become high enough to cause insulation failure of the windings. This induced voltage is highest before the rotor begins to revolve and decreases as the speed increases, becoming zero at synchronous speed. A field coil that is short-circuited will usually be cooler than the other coils unless the machine has been in operation long enough for the temperature to equalize throughout the field structure.

Two or more grounds in the field coils will short-circuit one or more coils out of circuit.

After the motor has been brought up to synchronous speed and should one of the phases become open, it will continue to operate single-phase unless loaded sufficiently to pull it out of step. Unless lightly loaded, the motor would take sufficient current to cause excessive heating of the windings in use. After the motor has shut down, it will not be possible to start again until all phases are alive.

Short-circuits in the stator winding will generally cause local heating which can be detected with the hand, especially if the motor is started cold and is operated for a short period. This does not give the high temperature of the defective coils time to spread to the other parts of the windings.

One ground in the winding in conjunction with another ground on the external circuit will short-circuit a section of the winding if the frame of the machine is grounded. Two grounds in the same phase, with the rest of the system insulated, would short-circuit a section of this phase winding. A ground in each of two different phases would cause a short-circuit between phases and in most cases would trip the circuit breaker. However, it is possible for a ground in each of two phases to occur in such a way as not to open the breaker but cause heating of the windings.

Incorrect connections of the stator windings are something that would generally be found only on a new motor or one that has been repaired or rewound. Short-circuits in coils or groups of coils, grounds, open-circuits in part of a winding that is connected in two or more parallels, will all cause the current in the different phases to be out of balance. If trouble is being experienced with a synchronous motor heating, one of the checks that should be made is to see that the current and voltage per phase are balanced.

If the bearings become worn sufficiently to let the rotor out of the center of the stator bore, it may cause heating of the windings, especially if they are grouped in two or more parallels. However, on account of the comparatively large air gap, heating from this cause is not so liable to occur on a synchronous motor as on an induction motor with its short air gap. It is nevertheless advisable to keep a close check on the air gap and keep the rotor centered, if for no other reason than to prevent excessive loading on the bearings.

There are a number of other troubles that may occur, but these have mostly to do with starting the motor and getting it into service and will be made the subject of another article.

At the critical or first vibrating speed of a turbine the period of vibration equals that of the speed, so that a shaft that vibrates 2,000 times per minute if standing still and subjected to a mechanical shock, would also present critical vibration at a speed of 2,000 r.p.m. On the other hand, at the critical speed the relation of centrifugal force, due to any unbalance and the resulting resistance of shaft deflection, is such that the centrifugal pull would increase the shaft deflection to an infinitely large amount. After critical speed, or in other words, at a few revolutions above, there would tend to be an infinitely large shaft deflection in the opposite, or negative, direction. In the latter case the heavy or unbalanced part of the wheel would tend to run out of true so the light side of the rotor would be marked with a stationary pencil. These points are so close together that if a turbine is brought up fast through the critical speed, there will be little deflection or vibration noticeable, as there is not time for vibration to build up and the shaft to take an abnormal deflection. Many turbines are operated below the critical speed, so that this point is not reached. An evenly loaded shaft would tend to have an infinite number of critical speeds higher than the fundamental. Any shaft provided with rotor strong enough may reach other points of critical vibration higher than the first one.

The Purchasing of Power

By A. ULMANN, JR.*

OWING to the rapid increase in the costs of fuel it is becoming more and more difficult to produce power at a reasonable cost in small plants. This is not a temporary condition, but has come to stay and is a situation that must be faced by all power users and particularly by the engineer, upon whom depends the costs of production in the industrial world. It is not a question that can be solved by commercial methods solely, nor can we hope for any more than a temporary relief by increasing our mining and transportation facilities. Improvements in mining and transportation may bring decreased costs for a time, but the increasing population and the inevitable depletion of our fuel resources will soon nullify the gain.

The large central station has proved to be a step toward the solution of this problem, as it is able to produce power at a high thermal efficiency, and owing to the well-known commercial advantages of wholesale production and marketing of a commodity by experts, the sale price can be the minimum. At the present time, however, the wholesale idea is not complete as practically all the large power companies are forced to carry on both a wholesale and retail distribution of their product, with a resulting disadvantage to themselves and to certain types of consumers.

If we were to carry this economic principle to its completion we would segregate the wholesale and retail distributions. Practically all power would be produced wholesale in very large plants and distributed and sold wholesale to retailing companies throughout the country.

Solution of the Power Problem

From this principle has come the conception of the Superpower and Giant Power ideas, and in these probably lies the solution of our present economic difficulties. With the plants at or as near the mines as an adequate water supply may be obtained, we are assured of two great advantages—the disappearance of, or a substantial reduction in, the cost of transporting the coal, and the resulting relief to the railroads of the removal of this freight from their lines or the segregation of the bulk of the traffic to certain lines.

A great many objections have been raised, mostly of a technical nature, to this plan, but they are all easily answered in a few words. Twenty years ago it would have been impossible to accomplish. Today, owing to the advance in the art of power production and distribution, it is feasible, and twenty years hence continued progress in the art will have changed it from an ideal to a thoroughly practical and workable principle accepted by engineers in general.

The question then arises as to what advantage the individual consumer will derive. A common and erroneous idea is that power rates will be reduced to an absurdly low figure. It is possible that the present rates will be reduced somewhat, but the great benefit to the consumer will be the checking of the present tendency of rates to rise and the preservation of the normal rate far longer than is possible under existing conditions.

Another erroneous general idea is that all individual power plants will disappear and that all power will be furnished by the superpower system. This will not be true, because a great many of the conditions that at present govern the production of power in individual plants will still be in force and the engineer and plant owner will always have to face the problem as to whether or not it will be more economical to purchase power.

When to Buy Power

In a great many cases the decision to purchase power can be arrived at easily, the comparison of cost being very direct, owing to the fact that power is required only for the manufacturing process. The location of the plant also has a great bearing on the problem, as it may preclude the possibility of coal storage, fuel and ash handling costs may be very high, the cost of water great, and the cost of real estate may impose a heavy fixed charge on the power plant.

There are several classes of industrial plants, however, that require large quantities of steam in their processes and therefore, without question, must have adequate boiler equipment. In this case engines may be used as reducing valves, and the resulting power will then be in the nature of a byproduct. But even here many varying conditions must be taken into account, and the rule is not hard and fast nor the solution quite so obvious as at first may appear. The following cases will show some varieties of application.

Plant *A*—A large chemical plant making bulk acid and other large-bulk, low-priced products, generates its own power. About half the steam generated is sufficient for process. It is reduced from 180 lb. pressure to 25 lb. by expanding through two non-condensing engines. The rest of the power required is generated in multi-stage, condensing, turbo units of the most modern and economical type. About 50 per cent of the power generated is used to pump the large amounts of process circulating water required.

Plant *B*—A tannery requires all the steam generated for process steam and hot water. All the steam passes through non-condensing engines, reducing the pressure from 125 to 15 lb. per sq.in. At times live steam must be admitted to the low-pressure lines to make up a deficit in the exhaust steam from the engines producing the required power.

Plant *C*—A chemical plant of essentially the same type as Plant *A* purchases all its electrical power and maintains boilers having a total of 20,000 sq.ft. of heating surface to furnish steam direct to process at 180 lb. per sq.in. and 100 deg. superheat. This curious condition was brought about by the fact that the major portion of the process consisted of a distillation requiring a temperature so high that low-pressure steam would have been useless.

Plant *D*—A mill producing artificial silk from raw material to finished, spun yarn, purchases all its power and maintains a large boiler house to furnish steam to the process. In this case the process steam is reduced from 180 to 45 lb. per sq.in., by expanding through

*Department of Mechanical Engineering, University of Pennsylvania.

engines driving a number of ammonia compressors to produce a large amount of refrigeration required in the process.

Plant *E*—A forging mill making medium and light forgings purchases all its electric power for machine shop and furnace blowers and maintains a large boiler house to furnish steam for steam hammers and hydraulic presses. In this case the steam must be of high pressure.

Plant *F*—A certain steel plate mill, having open-hearth furnaces and the necessary plate rolls, generates all its own power. Direct-connected Corliss engines drive the rolls and send their exhaust steam through a regenerator to a low-pressure condensing turbo-generator unit to generate power for shears, cranes, blower motors, lighting, etc. A large portion of the steam is generated in waste-heat boilers, using the sensible heat in the exhaust gases from the open-hearth furnaces.

Plant *G*—A paper mill located in the Ontario hydro-electric region purchases all its power and generates steam for process by means of electric boilers. The electric boiler is a recent development in steam generation, and in spite of its very high thermal efficiency, can be applied only in districts where electric power is exceptionally cheap and coal very costly.

Plant Classification

From these general examples it is possible to classify in general industries as to whether or no they should purchase power.

Class 1—Plants requiring power for process, no steam being required except for heating buildings in winter in general purchase power.

Class 2—Plants requiring both power and steam for process, in general generate their own power. However, a careful analysis may prove the reverse to be advisable as may be noted from the examples cited.

Class 3—Plants whose processes give a large amount of byproduct or waste that is available as a fuel, should generate their own power. Some of these byproduct fuels are: (1) Gashouse tar; (2) fuel-oil and oil-refinery wastes; (3) blast-furnace gas; (4) wood waste, sawdust, etc.; (5) sugar-cane bagasse; (6) gashouse coke; (7) straw, corncobs, etc.; (8) cannery wastes and refuse; (9) sensible heat in waste gases from open-hearth furnaces, blast furnaces, cement kilns, etc.; (10) coke breeze; (11) spent tan bark; (12) coal slack and culm. It is also an economic obligation for plants of this class to use all waste sources of power, as by so doing large quantities of primary fuels are released for other industries that have no byproducts available.

If it is decided to purchase power for any given installation, it is quite necessary to have a competent engineer go over the load conditions that are to be met so that the most advantageous rates obtainable from the central station may be applied. In most cases power rates vary with the size of the consumer's demand and the large consumer obtains a better rate than the smaller one.

In order to safeguard operating conditions, the central station limits the consumer to a certain stated maximum demand for any given set of rates and also charges a fixed amount per month as a "stand-by" charge to defray overhead expenses such as book-keeping, meter reading, maintenance, interest, and depreciation on the transformers and equipment for metering and delivering the current to the consumer. This "stand-by charge" must be paid whether or not current is used. Methods of arranging these charges vary considerable with different companies, as do also the actual rates charged.

Once having made the decision to purchase power, the services of the engineer are not at an end. The plant must be designed to operate economically, and conditions must be checked up from time to time in order to insure economical operation. To the lay mind it seems as if, once having established connection with a central source of power, all that remains to be done is to use the power and pay the bill. But as almost all central-station power is in the form of alternating current, unless it is used with judgment, many surprising things may happen.

The Status of the Engineer

It will, no doubt, be of interest to discuss here the functions of an operating engineer who finds himself in charge of the equipment of a plant operating on purchased power. First it is necessary to become thoroughly familiar with the schedule of rates and then

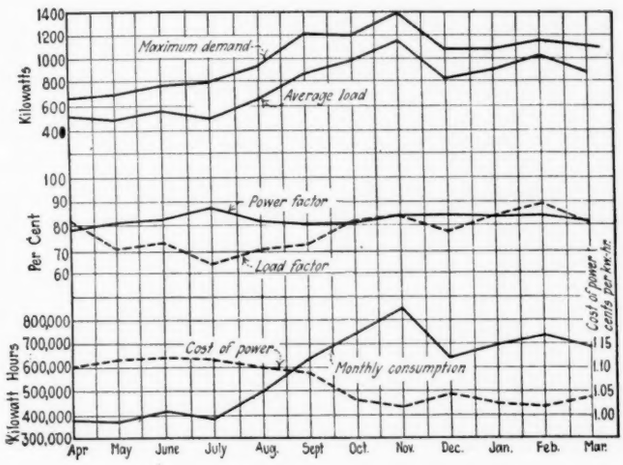


Fig. 1—Load record for one year

to institute a set of records of the power conditions so that they may be checked both daily and monthly.

Rate schedules vary greatly in form and billing. Some are very simple, as for example the "flat rate" used for small consumers and the "differential rate" which gives a decreasing cost of power as the consumption increases. To both these forms is attached a "minimum charge" which must be paid whether power is used or not. A more complicated form is used in the case of large consumers, which takes into account variations of load and power factors and gross consumption. There are many methods used to accomplish this, and for the sake of an example one method will be explained.

A certain industrial plant had the following contract for power:

(*a*) A stand-by charge of 200 kw. was charged for at the rate of $1.70 per kw.

(*b*) The maximum allowable five-minute demand was 1,500 kw. as metered at 90 per cent power factor, the rate being $1.30 per kw. for the maximum demand less the 200 kw. of the stand-by charge.

When the power factor was other than 90 per cent, a correction was made to the maximum demand as follows:

M = Metered five-minute maximum demand.

m = Maximum demand corrected.

P = Power factor observed and expressed as a fraction.

Then $m = \frac{0.9\ M}{P}$

From this it is noted that when P is less than 0.9, m becomes greater than the metered maximum demand, and when P is greater than 0.9, m becomes less than M. Then the cost of this item of the bill is calculated by the formula, $(m - 200) \times \$1.30 =$ cost.

(*c*) Metered Consumption at the following rates: First 30,000 kw.-hr. @ $0.0125; second 70,000 kw.-hr. @ $0.008; balance of kw.-hr. @ $0.0065.

A sample bill follows showing the complete method of billing a month's consumption under these rates:

Bill for October 19..

Power factor 83.6 per cent.	
Stand-by charge, 200 kw @ $1.70	$340.00
Maximum demand, 988 kw @ $1.30	1,284.40
	$1,624.40
Metered consumption:	
First 30,000 kw.-hr @ $0.0125	375.00
Next 70,000 kw.-hr @ $0.008	560.00
591,700 kw.-hr @ $0.0065	3,846.05
Total	$6,405.45
10 per cent increase in rates	640.54
Total	$7,045.99

From this bill may be calculated the following data:

1. Maximum five-minute demand metered, kw	1,003
2. Average load on plant, kw	903
3. Load factor, per cent	84.2
4. Power factor, per cent	83.6
5. Total consumption for month, kw-hr	691,700
6. Cost of power in cents per kw.-hr, cents	1.020

In this particular plant the data thus obtained from the bills were plotted each month and a chart kept that gave a graphic representation of the performance of the plant. A reproduction of this chart for one year is shown in Fig. 1. This is a valuable chart to the operating engineer, as it gives him a vivid picture of what is going on, and combined with a thorough knowledge of the plant, he may obtain warning in advance of what is going to take place in the future. In addition there should be kept a daily record of the same data as nearly as possible from the meters installed. The daily record serves as a check on the billing record, aids in explaining any abnormal jump in the cost of power and shows up the irregularities and peculiarities in the plant load.

Further, a second chart, Fig. 2, was made up so that the cost of power for any given set of conditions could be easily calculated. This is a nomographic chart calculated from the method of billing that gives accurately the cost of power for any set of conditions and serves as a check on the bill. As indicated on the chart, a line is drawn from the load factor to the power factor, and from the point of intersection of this line with the mid-axis marked "Cents per kw.-hr.," another line is drawn to the corresponding monthly consumption on the axis farthest to the right. The sum of the two amounts of money indicated at the ends of this line is the required cost per kilowatt-hour.

As an illustration of the use of this chart let us see what the cost of power would have been if the power factor in the billing shown had been 100 per cent in place of 83.6 per cent. By reference to the chart it is found that the cost of power would have been 0.983 cent per kilowatt-hour, or a saving of $\frac{1.02 - 0.983}{1.02} \times 100 = 3.63$ per cent.

As another illustration of the use of these charts, let us suppose that it is proposed to install power-factor rectifying equipment in this plant. Will it pay to do so?

From Fig. 1 can easily be found the average load and power factors for the year and also the average monthly consumption; then from Fig. 2 may be found the corresponding average cost of power, enabling the cost for the power-factor guaranteed by the manufacturer of the equipment to be found and the yearly saving calculated. If this amount is substantially greater than the additional charges for operation and interest on the money invested and depreciation on the equipment, it will pay to make the installation.

With these charts at hand it is possible for the engineer, with the co-operation of those in charge of the

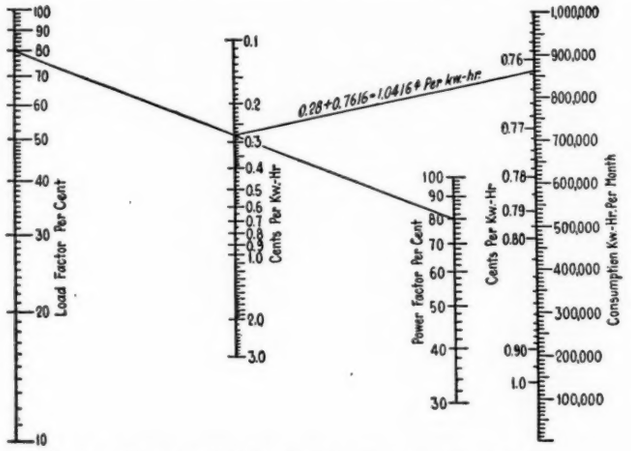


Fig. 2—Nomograph determines actual cost of power

manufacturing process, to make a great many adjustments that will improve the load factor and also the power factor. In the plant in question the load factor was good because there was a large pumping load which was uniform throughout the day, as a great deal of water was required continuously for cooling jackets and condensers used in the manufacturing process. Ultimately, all the motors used for pumping were changed to synchronous motors and the power factor was kept around 95 per cent without any trouble.

One part of the manufacturing process consisted of a battery of forty stills that had a very poor load factor. Each still was equipped with a 10-hp. induction motor to operate agitating arms, and as the distillation neared completion the power required for agitation became very great. It was the custom to charge all these stills at once in the morning and run them all together. The result was that at the end of the run a heavy power peak occurred. The cycle of operation was changed so that one-quarter of the number of stills required were charged every six hours with beneficial results as shown by the following data.

With 35 stills in operation as originally operated, the instruments showed: Mean hourly load, 305 hp.; maximum 5-min. demand, 511 hp.; load factor, 59 per cent.

Operating 35 stills on the new basis gave: Mean hourly load, 306 hp.; maximum 5-min. demand, 329 hp.; load factor, 93.0 per cent.

This change was made in September, and by reference to Fig. 1, it is noted that the load factor of the plant was improved about 10 per cent with a corresponding decrease in the power cost.

Worthington Builds Double-Acting Two-Stroke-Cycle Diesel Engine

A NEW design of two-stroke-cycle, double-acting Diesel engine has been developed by the Worthington Pump & Machinery Corporation at its Buffalo works. The engine combines a fuel economy comparable with that of the best existing types of Diesel engine, with dimensions, weight and construction cost per horsepower approaching those of reciprocating steam machinery. The first unit, which is a single-cylinder engine, is rated at 600 to 800 hp. at speeds of 90 to 120 r.p.m., the cylinders being 27 in. in diameter by 40 in. stroke.

It is the intention to build engines of three, four, five or six units placed on a common bedplate and working on a common shaft.

The frame and running gear on the engine follow conventional lines. The frame is cast of box section; it is entirely enclosed with oiltight doors suitable for lubrication of all parts under pressure, but is separated from the cylinder by a partition having a stuffing box, so that no exhaust gas can penetrate the crankcase, even should the piston-rod stuffing box of the working cylinder leak. A scraping ring arrangement on the piston rod prevents lubricating oil from traveling from the crankcase into the cylinders.

On the frame is placed an extension to support the cylinder base, which is bolted directly to the bedplate by means of four tie bolts, relieving the frame of all tensional stresses. This base is a single rectangular block containing a central vertical cavity for the cylinder ends and the necessary passages for the scavenging air and exhaust gases.

Novel Cylinder Design

In the construction of the cylinder the designers proposed to themselves the elimination of the customary cylinder head. This part of the oil engine has already been more or less subject to fracture. Engines, after operating several years without trouble, have suddenly developed head fractures; the cause doubtless being connected with the subject of metal fatigue. It was decided to eliminate the cylinder head and construct the cylinder and head in one piece out of a steel forging.

The top and bottom cylinders are alike, being in shape quite like an air bottle. These steel forgings are made with a substantial shoulder on the outer circumference suitable for securing the shell to the cylinder base by means of a clamping ring *A*, which, in turn, is bolted to the cylinder base by heavy studs, similar to the cylinder-head studs in engines of conventional design. Into this steel shell is pressed a cast-iron liner *B*, which contains, at the open end, the ports *C* for the introduction of scavenging air and ports *D* for the outlet of exhaust gas. The free end of this liner rests on a heavy flange projecting inside the center bore of the cylinder base, in which bore the upper and lower cylinders are guided, thus securing perfect alignment, this joint being metal to metal. Around each cylinder is placed a light cast-iron jacket *E*, bolted to the outer end of the cylinder and guided in the clamping ring against which it is tightened by means of a stuffing box and gland *F*.

The cooling water is introduced in the center of the cylinder base and entering cored passages in the port bridges, moves upward through the top cylinder jacket and at the same time downward through the bottom cylinder jacket. The two liners are free to expand

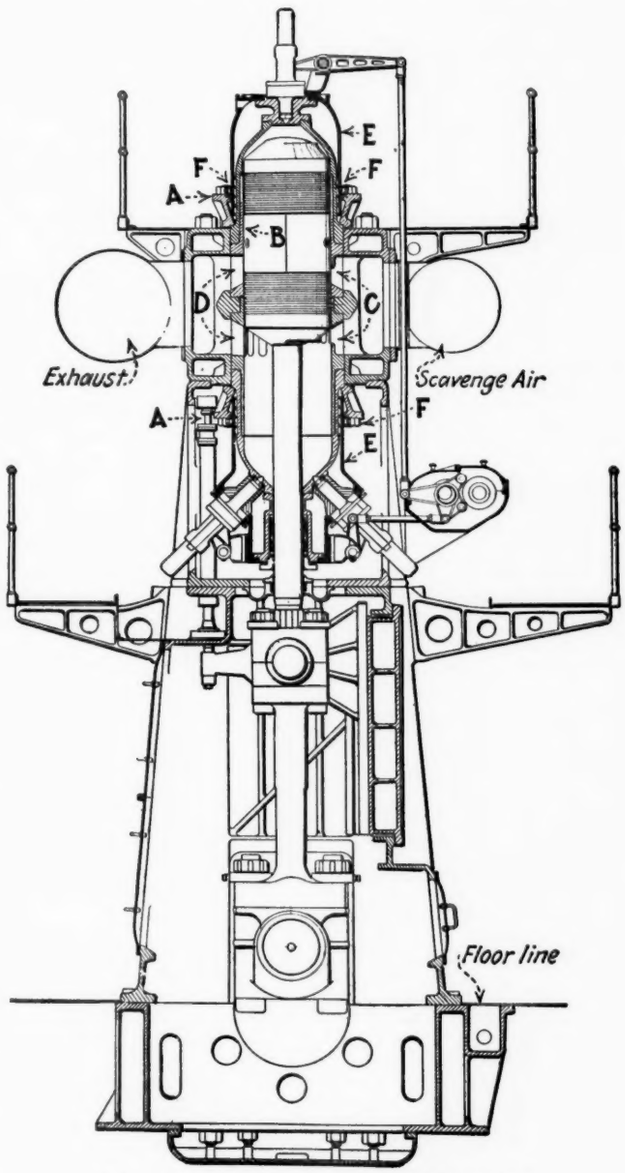


Fig. 1—Cross-section of double-acting Worthington Diesel

from the clamping rings toward the hot ends of the cylinder where combustion takes place, and each cylinder end has its own independent set of ports for air and exhaust.

The top cylinder has one fuel valve, the bottom cylinder two fuel spray valves furnished with suitable nozzles for directing the jet of fuel-air mixture. The atomizing device consists of the customary set of slot-

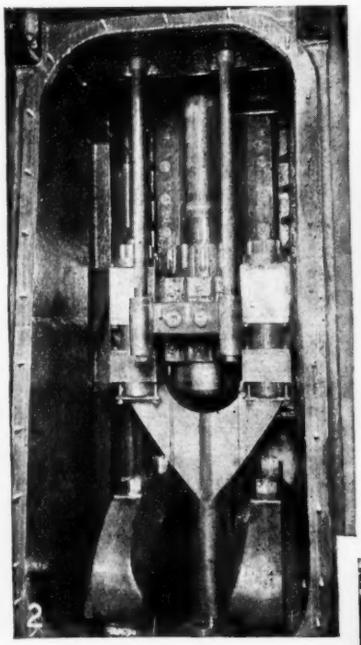


Fig. 2—Connecting rod and telescope piston cooling pipes

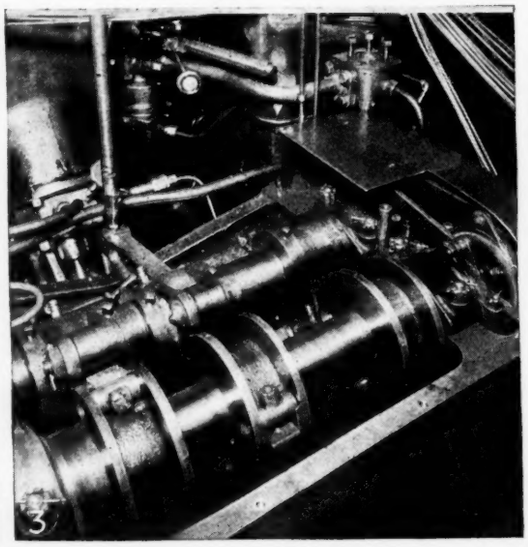


Fig. 3—Camshaft assembly

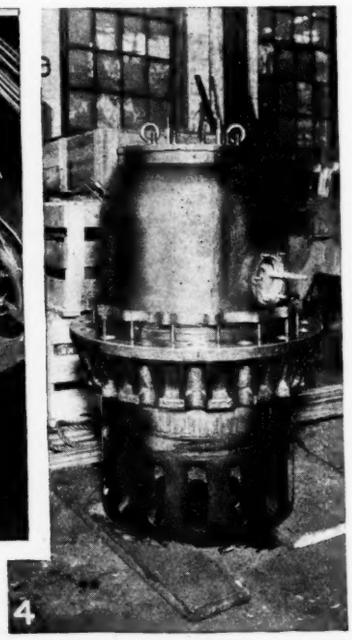


Fig. 4—Cylinder and removable jacket

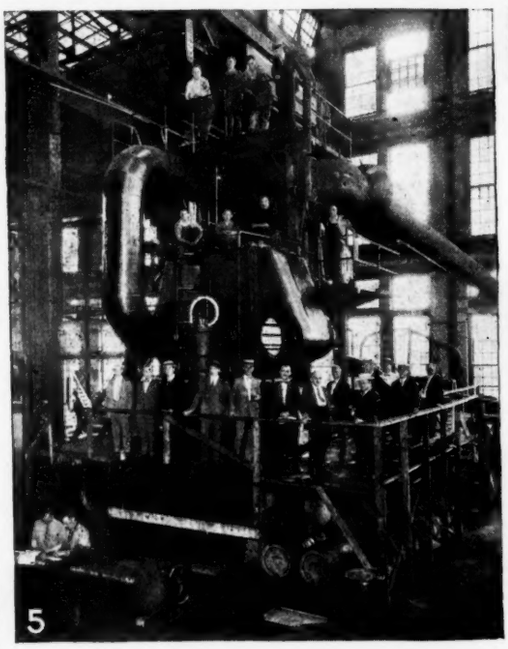


Fig. 5—Air-pump side of engine

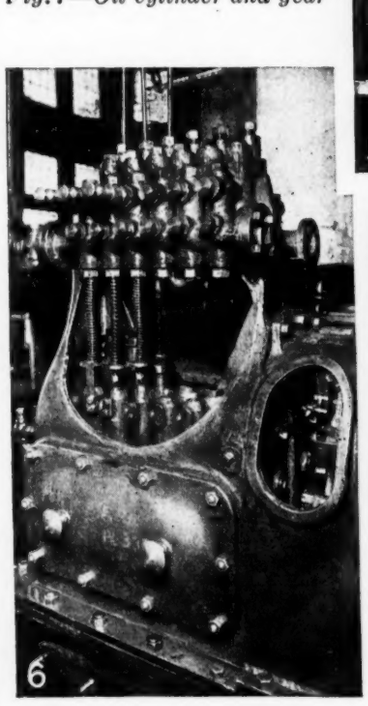


Fig. 6—Fuel pump and overspeed governor

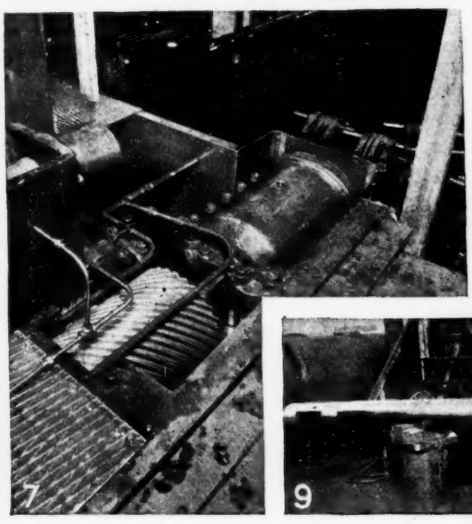


Fig. 7—Oil cylinder and gear

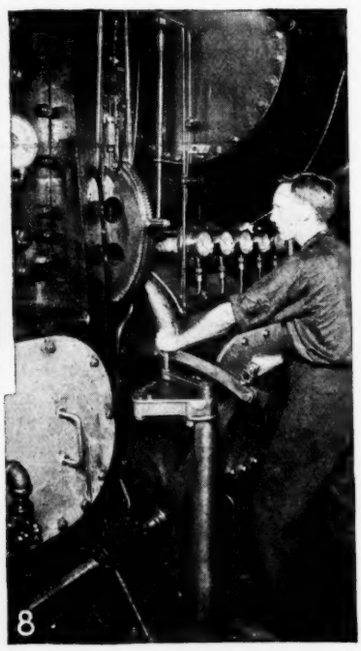


Fig. 8—Interlocking control gear

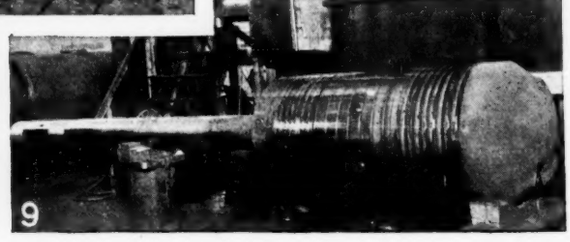


Fig. 9—Water-cooled piston and rod

ted disk and cone. The flame plate carries four drilled openings and is of conical form with only the tip exposed to the cylinder heat. The bottom spray valves have two openings in the flame plate which are so directed that the charge does not impinge upon the piston rod, but is injected tangentially into the space between the rod and cylinder wall. In these lower spray valves the tendency of the fuel to settle at the lower side and away from the needle tip is avoided by the construction of the atomizing device. This is different from that used in the top valve and consists of a hollow sleeve carrying several holes in its cylindrical surface. The admission of oil through these holes is at a velocity high enough to prevent its coming to a state of rest.

Built-Up Piston

The piston is built up of two single-acting pistons, each resting on a flange on the piston rod, to which it is secured with a number of heavy bolts. The center part of the piston consists of a sleeve in halves, located on the piston rod by recessing, leaving the two ends free to expand. The piston heads, which are of forged steel, have deflectors on the air side, but on the exhaust side are shaped to allow easy outlet for the exhaust gases.

It is the intention to have a closed fresh-water system for even marine units. This appears to be the most desirable arrangement for efficient cooling, cleanliness of all jacketed spaces, absence of corrosion, open outlet from jackets and pistons, simplicity of the pumping arrangement and safeguarding the circulating oil system in which a little fresh water is not harmful.

The valve motion is designed on conventional lines with one cam for each spray valve. Each valve lever oscillates round an eccentric on the fulcrum shaft, which can be turned through a small angle by hand for reduction of the valve lift at low speed. The cams are symmetrical and can be used for running in both directions by rotating them through an angle of 34 deg. in relation to the crankshaft. A spur gear on the main shaft engages an idler, which drives a spur-gear wheel keyed on a horizontal layshaft in the bedplate in front of the engine. This shaft can slide longitudinally in its bearings and, as the spur gears have helical teeth, this motion will cause it to rotate through an angle of 34 deg. for the full travel of the layshaft. The camshaft is driven from a bevel gear bolted to the sleeve by the intermediate vertical shaft and will thereby be displaced the proper angle when the layshaft slides from one extreme position to the other. To the forward end of the layshaft is attached a piston in the bore of which the layshaft can freely revolve. This piston travels in a cylinder under oil pressure and is held tight against a face in the one or the other end of the cylinder for either ahead or astern rotation of the engine. Reversing is thus reduced to the turning of a four-way cock, admitting oil on one side and allowing oil to escape from the other side of the piston.

Double-Acting Scavenging Pump

Scavenging air can be supplied to these engines either from a displacement pump, driven most conveniently by the engine itself, or by a turbo blower. The present unit receives its air from a fourth part of a scavenging pump intended for a four-cylinder engine. The displacement of the scavenging pump is 50 per cent in excess of that of the engine itself, and each pound of excess pressure on the suction or discharge side of the scavenging piston will absorb 1½ lb. of the brake m.e.p. of the engine. For this reason pressure-actuated compressor valves were discarded and a light slide valve correctly timed and opening large passageways for the slowly moving air, was used. These valves are driven by rods and levers from a layshaft geared to the engine shaft.

The pump in use at present has two simple acting pistons placed in tandem, but it is the intention to use a double-acting cylinder for the scavenging pump.

In the standard scavenging pump the low-pressure stage of the injection air compressor will be placed above the pump and the pump piston rod will carry the single-acting piston of this first stage of the compressor. The other three stages will be located on the rear side of the engine in a single casing and driven through a beam from the same connecting rod that drives the scavenging air pump; in stationary units the compressor will be alongside the pump and will be driven by a separate crank.

Calculations as to weights and costs of production of this design lend much encouragement to the hope that the double-acting engine will go a long way toward overcoming the objections to the use of large Diesel engines. These calculations indicate substantial savings, both in weight and in cost, over single-acting Diesel engines of similar power.

Notes on Switchboard Operation

By J. Elmer Housley

In quite a number of plants the complaint is made that switchboard pilot lamps have a short life although the voltage rating of the lamp is the same as that of the circuit. The trouble is apparently caused by poor ventilation of the lamp, which is usually set in a small hole drilled in the panel and the circulation of air is cut off by switches and wiring behind the panel and benchboard. As a result the lamp operates at an excessive temperature and the filament may burn out in a short time. A satisfactory way to secure the expected life of the lamp is to use a lamp rated at 150 volts for circuits operating at 125 volts, and ordinarily the lamp will appear of sufficient brilliancy for the purpose. In addition protection is given against overvoltage on an unregulated exciter control circuit and against overvoltage while charging the control storage batteries where they are used.

In the maintenance of control and meter circuits it is essential to keep a record of the replacement of 13,000-volt fuses protecting the potential transformers in order to detect irregularities which may develop into serious trouble. A record will often indicate some trouble which, while of a minor nature in itself, may cause the loss of a transformer in time. One method that has been found to be simple and effective in keeping a check on such matters is to number the new fuse when it is installed by writing on its case the location number and date installed. For example "Gen. No. 1 *BA*, 8-1-24." The numbers are taken from equipment number and phase letters.

Whenever a fuse is blown, the fuse record and any information available concerning unusual conditions is noted on a sheet provided for the purpose. The record will assist in picking out the best make of fuse for the purpose and indicate the effectiveness of the design of the transformer and meter layout.

Turbine Blades Move at Ten Times Safe Pulley Speed

THE pulley or flywheel speed of a mile a minute at the outside circumference, is well established as a reasonable limit. Modern engineering, however, has made it necessary to utilize ten times this as a safe tip speed for some classes of turbine blades.

BY EUSTIS H. THOMPSON*

AN EXPRESS train running at sixty or eighty miles an hour represents an engineering achievement with respect to speed and safety. If a fast airplane were to fly in the same direction, the comfortably seated traveler might find himself overhauled and passed. Should the train appear to suffer by comparison, there is consolation in the fact that the plane does not afford safety or comfort in anything like an equal degree.

The speed of a mile a minute, characteristic of fast passenger service, is also the safe limit of velocity for built up rims of cast-iron flywheels and pulleys. This, however, is far too slow for some of the more highly specialized rotating machine elements. An electric train going sixty miles an hour would, in all probability, receive its energy primarily from a steam turbine, some blades of which move five or ten times as fast.

In many turbines the tips of the vanes at the exhaust are whirling at 600 miles an hour, with less noise than a single train wheel makes in ordinary operation. If going in a suitable course, a high-speed blade would outdistance the fastest airplane or encircle the earth in about two days.

The question naturally arises, Why such high turbine blade speeds and why so many rows of blades? In an engine the pressure of expanding steam acts against a piston and speed is of little consequence. In a turbine however, steam expands unrestrainedly in nozzles and gathers momentum, like a boulder rolling down hill. The available pressure pushes against the steam instead of the piston, and being comparatively light, the steam acquires a high speed. In order to do work with steam moving at high velocity, there are two general types of mechanical devices employed, the reaction turbine and the impulse turbine.

In the pure reaction-type turbine, at *A*, Fig. 1, steam is received without shock by rotating nozzles. It then expands in passing through, pushing them around in the direction of rotation. Similarly, gas generated at high pressure from powder, pushes a skyrocket or pinwheel, so that expansion in moving nozzles or blades characterizes reaction, the fundamental invention being attributed to Hero of Alexandria, in about 150 B.C. The first commercial application of this type is generally credited to De Laval, in Sweden, around 1883, who utilized it for driving cream separators. However, the illustration actually represents a type of machine built and sold by Foster & Avery, several of which drove sawmills in the vicinity of Syracuse, N. Y., 40 years before De Laval's machines appeared. These turbines sometimes attained tip speeds of 14 miles a minute, thus exceeding the present maximum commercial tip speeds appreciably. Avery also built what is believed to be the first steam turbine-driven locomotive.

*Assistant Editor of *Power*

Steam at *B* is delivered by the nozzle at a speed about equal to that of the buckets, which it therefore enters without shock. It expands in going through the blades, thus pushing them around by reaction. In commercial turbines steam is frequently delivered faster than the

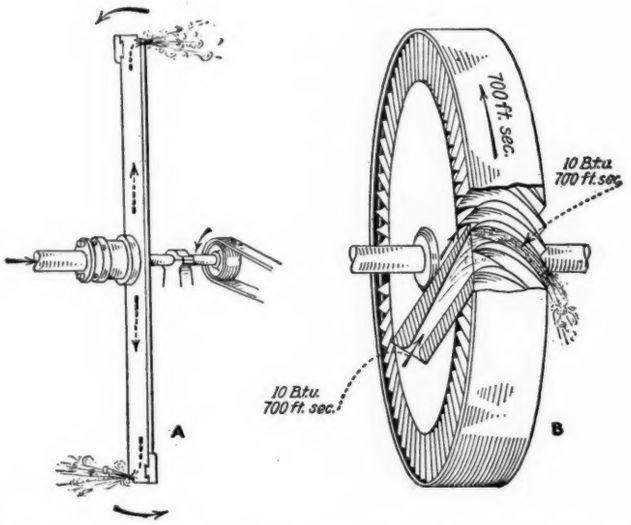


Fig. 1—Reaction-type turbines driven by expansion of steam in moving elements

Avery's turbine, at *A*, employed for operating sawmills near Syracuse, N. Y., preceded De Laval's reaction machine by many years. Tip speeds of 14 miles per hour were employed, eclipsing present commercial blade speeds.

Steam from a stationary nozzle as at *B*, equals or slightly exceeds the speed of the blades. The driving force is largely derived from expansion in the moving element, representing the Parsons type of steam turbine.

blades, so that it also pushes them with an impulse due to its speed.

Impulse turbines are indicated in Fig. 2. Generally speaking, expansion takes place in stationary nozzles and not in moving blades. Steam drives the blades by means of the shock or impulse, in the same way that air drives a windmill or sailboat. As explained in the Jan. 29, 1924 issue, the original terms, impulse and reaction, referred to motion produced in the direction of steam flow and against it, respectively. Since steam reverses its direction in the usual impulse blade, this would actually represent both impulse and reaction.

In practice there is always some little reaction present in impulse turbines and some impulse in reaction machines. In both types, operating at maximum efficiency, steam should be discharged as nearly as possible at zero speed with regard to stationary objects, or in other words, "standing still." It is evident that if steam were discharged at any velocity, say 100 ft. per sec., in a direction either with rotation or against rotation, more

work could be done by shooting this against additional turbine blades.

Putting the foregoing facts together, it is apparently necessary to give steam great speed and then to extract the energy by means of fast-moving blades. In order to bring these general conditions down to concrete facts, we will consider steam expanding from 100 lb. gage to atmosphere, in a theoretically perfect nozzle. This would reach a speed of $223.7 \times \sqrt{1,188 - 1,040}$ B.t.u. = 2,720 ft. per sec. On account of nozzle friction, this, however, would be less, probably $223.7 \times \sqrt{148 \times 0.90}$ = 2,570 ft. per second.

The application of the formula can be better understood if it is considered that the energy given up during expansion is first found. One pound of saturated steam at 115 lb. absolute contains 1,188 B.t.u. If expanded adiabatically to 15 lb. absolute, or atmospheric pressure, it will contain 1,040 B.t.u. These values may be obtained by referring to a Mollier diagram of steam conditions, as described in the May 20, 1924, issue, or calculated from values given in steam tables. The heat content at atmosphere after expanding from 100 lb. gage is much less than the total heat of steam at atmospheric pressure, generated from water at 32 deg.

Energy thus set loose by adiabatic expansion is 1,188 — 1,040 = 148 B.t.u., tending to push one pound of steam ahead. From the laws of kinetic energy and velocity, it can be shown that the speed attained, without losses would be $223.7 \times \sqrt{148} = 223.7 \times 12.17$ = 2,720 ft. per sec. or, for actual practice about 2,570 ft. per sec. The apparently insignificant single-stage turbines frequently utilize steam speeds exceeding those of some artillery projectiles.

A single-stage pure reaction turbine could not utilize this steam speed commercially. Suppose a reaction turbine as at *A*, Fig. 1, were to discharge this steam efficiently, which is at zero speed with regard to stationary objects. The nozzles in the arms would have to rotate at 2,570 ft. per sec., which would be high for ordinary materials. By building very long arms at few revolutions per minute, centrifugal force could be reduced so as to make this safe, but it would require an unreasonable amount of space and material. Commercial costs demand high rotative speeds.

A multi-stage turbine, however, with average peripheral speeds of 600 to 800 ft. per sec., could expand this in several reaction arms. An expansion giving up 10 B.t.u. of energy would produce about 700 ft. per sec., representing a commercial blade speed. Therefore $\frac{148}{10}$, or 15 turbines like *A* in Fig. 1 would be required to utilize the entire 148 B.t.u. per pound.

A cheaper construction would be to use a number of blade rows like the one at *B* in Fig. 1. The stationary nozzle-shaped blades deliver steam at the wheel speed of 700 ft. per sec. approximately speaking, neglecting for the present the angularity of steam to the blade. The wheel blades expand this again to 700 ft. per sec. discharging at zero velocity with respect to stationary objects. This requires fifteen rows altogether, each expanding 10 B.t.u., which would make eight stationary and seven moving rows. Since this combination would not work out in practice, there should be eight moving rows instead of seven. Therefore a lower blade speed and lower heat drop per stage, such as about 9 B.t.u. without going into refinements of actual requirements, would make a complete machine. The Hell Gate turbine described in the Aug. 8, 1922, issue, expanding steam from 250 lb. 200 deg. superheat to 29 in. vacuum, contains 136 blade-row expansions, half of which are stationary and half revolving. Steam is delivered to the moving blades somewhat faster than blade speed, as in most reaction-type turbines, tending also to push them around to some extent by impulse. A pure reaction type as at *B*, Fig. 1, would require more blade rows if of the same speed.

Utilizing steam velocity by the impulse principle is in some ways quite different, although, as in the reaction type, steam should be discharged at about zero velocity with regard to stationary objects. If it

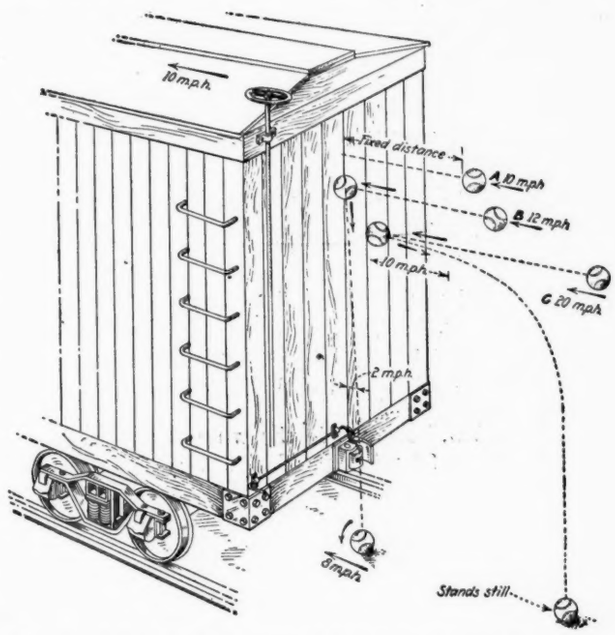


Fig. 3—A baseball thrown at twice train speed gives up all of its energy on striking the car

Ball *A*, at train speed, gives up no energy, as it does not strike. Ball *B*, slightly faster, gives up a little energy by impact, while *C*, thrown at twice train speed, rebounds and gives up all its energy, representing 100 per cent efficiency.

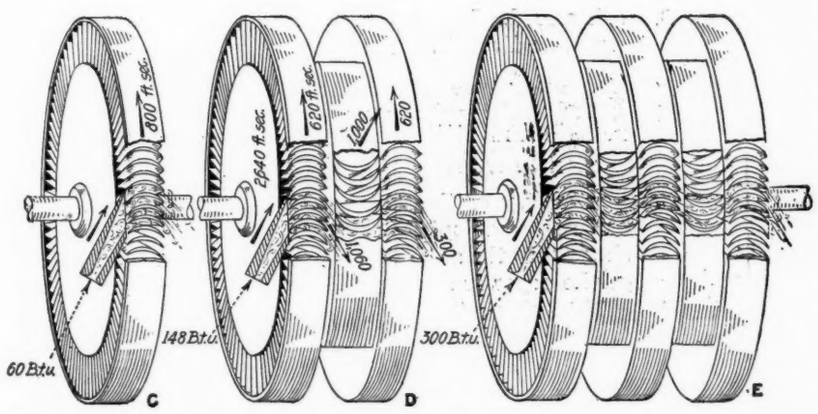


Fig. 2—Energy utilized in single- and multi-velocity stage impulse turbines

Speeds in feet per second and also energy in B.t.u. per pound of steam utilized by nozzle expansion are indicated

traverses a blade through approximately one-half turn, or 180 deg., as at *C*, Fig. 2, the steam must theoretically be supplied at twice blade speed. In practice, owing to the angularity of the nozzle to the blade, and some blade friction, this is usually slightly more than twice blade speed.

In order to bring out this principle, we will consider a baseball thrown ten miles an hour at a door standing ajar. The ball will give up considerable energy and move the door. If thrown 10 miles an hour at a freight car moving away also at 10 miles an hour as at *A*, Fig. 3, it will never even reach the car, but will stay a fixed distance away, if we neglect air friction and downward motion due to gravity. It gives up no energy and the efficiency is zero.

A baseball thrown 12 miles per hour at this train, at *B*, will hit the car and bounce away, giving up some energy. The ball will rebound slowly, which is 2 miles per hour theoretically with regard to the train. It will roll 8 miles per hour toward the train when it hits the ground. Here it gives up some energy, but is nevertheless very inefficient.

The ball at *C*, however, is thrown at twice the speed of the train, or 20 miles per hour. It rebounds at 10 miles per hour, as measured from the train. But since the train is moving 10 miles per hour in the opposite direction, the ball really moves at $10 - 10 = 0$ speed as measured from the ground. It will fall vertically downward and will not tend to roll.

The ball *C* therefore gives up all its energy, representing 100 per cent efficiency. In the same way steam should move at twice blade speed, approximately, in order to impart all its energy, when it rebounds in a parallel path. The wheel at *C*, Fig. 2, which represents a Rateau stage, would receive steam at about twice blade speed. If the blades move about 800 ft. per sec., a single-stage impulse machine built at commercial blade speeds must expand to 1,600 ft. per sec., approximately, utilizing about 60 B.t.u. In practice the angularity of the nozzle and the effect of friction in the vanes would require more than 1,600 ft. per sec., or 1,740.

Steam Speed for a Two-Row Velocity Stage

In commercial turbines, a single two-row velocity stage, as at *D*, Fig. 2, would be employed in a small machine for the entire heat drop from 100 lb. gage to atmosphere. Here the one nozzle group gives the steam sufficient velocity to pass through two rows of moving blades. This is about four times the blade speed, in practice varying above and below this amount. A stationary row is required to reverse the steam direction after it issues from the first row of blades. Steam and blade speeds, approximately as they would be found in a commercial turbine, are shown. Ordinarily, steam is not discharged absolutely at zero velocity with respect to surrounding objects. Here it leaves about 300 ft. per sec. Also, there is a slight drop in speed through the stationary blades due to friction loss.

A three-row velocity stage at *E* may be employed for a condensing turbine at 100 lb. It is not as efficient as a turbine made up of many Rateau or single expansion stages. Three wheels of this kind could utilize the entire 149 B.t.u., in expanding from 100 lb. to atmosphere.

The multi velocity stages at *D* and *E* use stationary vanes to redirect the steam, making lower blade speed possible. Thus, at *D*, the buckets may move approximately at 620 ft. per sec., and with three moving rows as at *E*, about 300 ft. per sec. About 300 B.t.u., or more than twice the heat drop at *E*, can be obtained with blade speed slightly less than at *D*. On account of friction losses this construction is not so efficient in practice as a number of single stages at low blade speed, or as reaction stages.

A ten-stage impulse turbine utilizes a two-row wheel in the first stage together with nine single-row wheels to expand from 200 lb. gage 210 deg. superheat steam to 29 in. vacuum with blade speeds of 600 ft. per sec. The total heat drop is therefore 420 B.t.u. per lb. of steam. Allowing three B.t.u. for radiation, valve losses, etc., gives 417 B.t.u. to utilize. Taking 34.5 B.t.u. for each of the single-row stages, would leave slightly more than twice this amount for the first double-row stage, which would have $417 - 9 \times 34.5 = 106.5$ B.t.u. Steam speeds would therefore be about 1,300 ft. per sec. for single-row stages of 34.5 B.t.u. each, and the blade speeds are slightly less than one-half this in practice, or about 600 ft. per sec. for each of the nine stages. On the 2-row wheel, 2,300 ft. per sec. steam from the nozzles and 600 ft. per sec. blade speed are used. The steam speed is thus about 3.84 times the blade speed, corresponding to design requirements.

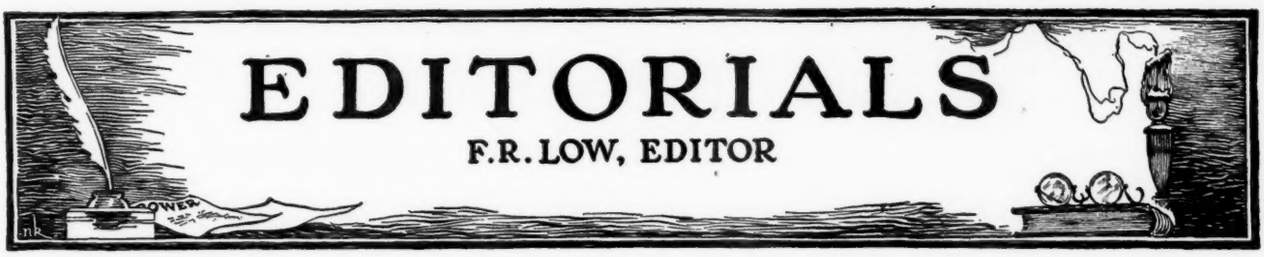
Cost of Water-Power Developments in Norway

According to Henry A. Pulliam, Chief Engineer, Board of Drainage Commissioners, and Director of Public Works, Paducah, Ky., who made a trip through Scandinavia with the World Power Conference Tour, government ownership of electrical public utilities prevails in 90 per cent of the 694,000 installed horsepower of these utilities in Norway. Both the national government and the various divisions of community government participate in this ownership. In the numerous industries dependent on hydro-electric power, having an aggregate installation of about 1,126,000 hp., between 90 and 95 per cent of the capital is privately subscribed. In 1922 the hydro-electric energy of Norway was divided about as follows:

	Hp.
Electrochemical and electrometallurgical industries	766,000
Wood-pulp industries	220,000
Other industries	140,000
Public utilities	694,000
Total	1,820,000

A survey of the costs of 36 hydro-electric plants in Norway, developing an aggregate of 1,450,000 hp., shows that the average cost has been $100 (375 kroner) per horsepower at the power house. During the period 1905-15 about 400,000 hp., was developed at costs ranging from $27 to $40 per hp., undoubtedly the cheapest water-power developments that have ever taken place. During the World War, however, some of the costs of the plants constructed were abnormally high. The operating expenses, similar to other countries, amount to about 10 per cent of the development cost for the larger plants, including interest and amortization, and 12 per cent to 15 per cent for the smaller plants.

High-tension transmission of the last few years has, by making possible the utilization of waterfalls remote from industrial centers, rescued Norway from the dependence of foreign coal for power production. However, in spite of this former dependence, by intense application to the fisheries and timber resources and to ocean shipping, the country has maintained a steady increase in wealth.



Burning Four Pounds of Coal To Obtain the Heat of One

THERE are few industries in which such a small part of the raw material is utilized as in a condensing steam plant. Remarkable improvements have been made in the over-all thermal efficiencies of these plants during the last twenty years, and the future holds promise for further improvements. However, when the most efficient steam plant proposed is considered, over seventy-three per cent of the heat in the fuel is lost between the bunker and the busbars under the best operating conditions.

Figures recently compiled and presented before the World Power Conference by E. W. Rice showed that in 1903 a 5,000-kilowatt turbine operating on steam at 175 pounds gage and 378 degrees F. at the throttle, resulted in an over-all plant efficiency of 9.2 per cent. Modern plants now in operation with units of 30,000- to 45,000-kilowatt capacity have more than doubled the over-all efficiency of twenty years ago. In new stations under construction using steam at 550 pounds and 725 degrees F. at the throttle in 35,000- to 60,000-kilowatt capacity turbines arranged for steam extraction for feed-water heating and single reheating between turbine stages, a plant thermal efficiency of 23.6 per cent is expected. For proposed new stations using steam at 1,200 lb. and 725 degrees F., in turbines of 100,000-kilowatt capacity arranged for two reheatings between stages, it is expected that an over-all thermal efficiency of 26.6 will be obtained.

Considering average operating conditions for such a super plant as proposed, if an average over-all efficiency of 25 per cent can be obtained, it will be about all that can be expected. Therefore in our most highly developed steam plants proposed for the future, we have the prospects of throwing away about 75 per cent of the heat in the fuel. If the prospects of increasing the efficiency of the steam plant of the future were as promising as they were twenty years ago, the promised 25 per cent over-all efficiency might be looked upon a little more favorably. But even going to the binary cycle, which is still in an experimental stage of development, the efficiency would be improved only a little over that for the proposed high-pressure plant operating on a regenerative cycle with 100,000-kilowatt turbines.

Where the exhaust steam can be used for heating, a kilowatt-hour can be produced for about 4,000 British thermal units supplied to the turbine, where with the proposed 100,000-kilowatt unit with all its complications, a kilowatt-hour is expected on 9,000 heat units, or 125 per cent more than are required for the combined power and heating plant. It must be admitted that there are many problems to be worked out in combined central heating and power plants. However, the introduction of very high-pressure steam opens up a whole field for study. Operating turbines on a pressure range of 1,200 to 100 pounds and using this exhaust in a central heating system should eliminate to a large degree the difficulties experienced with steam at medium pressures when used in such a system. These possibilities also apply to large industrial plants that require steam at medium pressures for process work and should greatly extend the possibilities of combined heating and power loads in industrial work.

Looking into the future, there are apparently two directions in which steam power developments may go—one the super plants in which four pounds of coal must be burned to obtain the heat of one, the other the combined heating and power plants of smaller sizes in which the heat of about two pounds of coal can be made available of every three burned. The latter should be worthy of serious consideration when the former offers little prospects of further improvement.

The Large Diesel Has Arrived

CENTRAL stations more or less set the fashion in power-plant engineering. This is one of the reasons that the oil engine has not achieved the popularity its operating record justifies. The central station is interested in large prime movers, and there has always been the objection that the oil engine was not suitable on account of its small machine capacity.

The action of the government in calling for bids on Diesel sets of four thousand horsepower may be taken as indicative that the large Diesel has been developed into a practical machine. Examination of the bidders' specifications reveals that most of the builders offered double-acting engines, both two- and four-stroke cycle.

There are many indications that the large oil engine has become a thing of fact. A European builder has accepted a contract for a sixteen thousand horsepower unit, basing his ability to construct such a machine upon the experience gained in the operation of a twelve thousand horsepower Diesel. A second firm offers units of ten thousand, while several do not hesitate to quote on units of over five thousand horsepower.

In this country builders have been very conservative, but several have proceeded far enough to be willing to quote with a specified delivery date upon the Panama Canal units. It is to be expected that such large units will soon be accepted by engineers as reliable prime movers.

Undoubtedly, the slowness of progress in Diesel construction has been due to metallurgical problems that have been most baffling. The cylinder bore has been limited in size by reason of past inability to construct a cast-iron wall thick enough to resist the internal pressure, yet thin enough to transmit the heat absorbed by the inner wall without overstressing the metal. A better understanding of the characteristics of metal and the adoption of other kinds of metal have increased

the bore limit to as high as forty inches, and there is no reason why bores equal to those found in large gas engines may not be finally used.

The problem of cylinder-head fracture has always been before the designer. Some have sought to eliminate this trouble by a head design whereby the velocity of the cooling water would be very high. Others have adopted a two-piece head construction using the outer part for strength, with the inner portion devoted to cooling only. In some of the newer engines the head has been eliminated by making the cylinder bottle-shaped with the fuel-valve cage serving as the cork. All these designs seem to overcome the fracture difficulty and permit the builder to increase the unit capacity of the machine. It seems that the Diesel of large capacity will eventually come into more general use.

Intelligence Will Be the Test

IS THERE a future for the isolated-plant engineer? Assuredly, yes—if he has brains and uses them. The isolated plant occupies a position on a par with that of the central station in the modern industrial state. Both are essential. Industrial power users can be divided roughly into three classes. First come those where the isolated plant has a marked natural advantage. In the main these are distinguished by a heating load large in comparison with the power load, but have as the same time sufficient power load to warrant the supervision necessary for the generation of power. In this class fall large steam laundries and the majority of chemical, paper and textile plants, to name a few oustanding examples. This class also includes cement plants, steel mills, etc., with their large quantities of waste heat.

At the other extreme are industrial plants with insignificant heating loads and situated in regions of cheap central-station power. A good example would be a machine shop in a warm climate and near cheap hydro-electric power.

Between these two extremes lies an important group of plants where the relative merits of purchased and home-made power depend on the local situation as to power prices, labor costs, etc., upon the size of the power load, the ratio of the power to heating load and the degree to which the two curves coincide.

In "border line" plants of this type the intelligence of the operating engineer is an important factor. The engineer's failure to keep informed of the best modern practice and to avail himself of everything that would reduce the over-all yearly cost of the power and heat service is not only a source of direct loss to the owner, but may swing these costs to a point where money could be saved by shutting down the isolated plant and purchasing electricity. Where such a situation arises, the engineer finds himself in an unenviable position. His claim that the plant is doing the best of which it is capable is tantamount to a surrender to the central station. His frank admission that the plant would be doing better if he had not fallen down on his job is an invitation to the owner to seek a more competent engineer.

Since this is the situation that exists in many plants, a continual weeding out process is to be expected with a final equilibrium obtained when all plants that ought to do so are buying power and all those that ought to generate their own power are doing so under the guidance of intelligent and competent engineers. For such men the isolated plant offers a worth-while future.

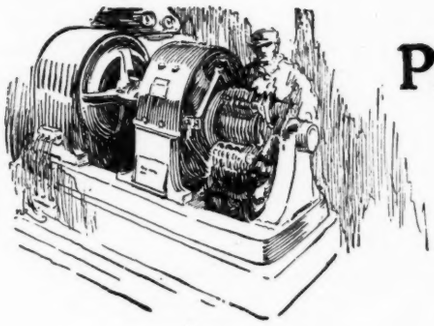
An Opportunity for Progress

IN THIS issue is published the report of the National Association of Stationary Engineers' Convention held last week in Grand Rapids, Mich. Two things stand out in particular in this year's convention—the large number of technical papers presented and the recommendation of the Technical Papers Committee for the formation of a committee on operating practice, both of which we note with a great deal of satisfaction. Those who in the past have attended the N.A.S.E. conventions and similar gatherings of other engineering organizations, could not help feeling that the stationary steam engineers had a great opportunity to make their annual meeting something more than a social affair and the election of the national officers.

Other national engineering organizations at their annual conventions not only elect their officers and provide many social functions, but also find time for a number of technical sessions at which are presented papers of general interest to the membership. In most of the organizations the papers and technical committee reports and, in some cases, papers and discussions presented at other meetings during the year are bound to form a record of the association's contribution to engineering. These transactions form some of the most valuable engineering literature available and have given these organizations a national and international recognition that they could never have obtained otherwise.

There is no reason why the National Association of Stationary Engineers cannot rise to the same prominence if its leaders and membership so wish. As pointed out in this year's technical papers report, "One of the outstanding activities of the National Electric Light Association and one that has given it the greatest prestige from an engineering standpoint is the work and report of its Prime Movers' Committee." What this committee is doing for the central stations, a similar committee composed of members of the N.A.S.E. could do for the industrial plant. Never was there a time when the need of a committee to do such work for the industrial-plant engineer was so great as at present, on account of the large number of new developments taking place in the power-plant field. The N.A.S.E. Technical Papers Committee has done a commendable piece of work in outlining a tentative program on operating practice for its association. It is now up to the membership to put it into action.

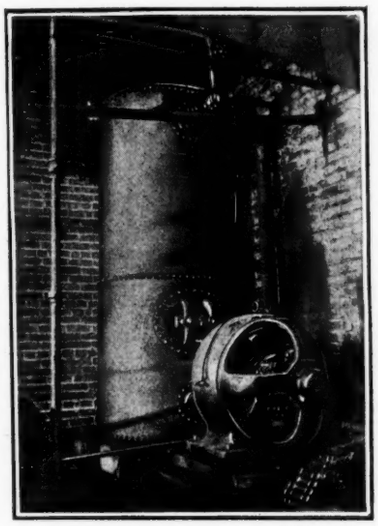
Power plants have been and are still operated with nothing more than a pressure gage to give an indication as to what is going on. This, however, is not the way high efficiency is obtained. Efficiency is based on an intelligent understanding of what is taking place in all the important operations of the plant, and this can be obtained only by proper records of these operations. But a meter, like any other piece of apparatus, must be maintained if it is to render the service for which it was designed. Unless this is done, no matter how valuable it may be, it only becomes one more piece of equipment to be neglected and fall into disuse. Unfortunately, many of the meters in a power plant can be neglected without seriously affecting the reliability of the plant, although the efficiency may suffer. Economy in power-plant operation can be attained only where efficiency and reliability are properly combined. Before this can be accomplished, the engineer must know the results his plant is producing.



Practical Ideas *from* Practical Men

Explosion in Compressed-Air Tank in Ice Plant

A peculiar accident happened at the plant of the Service Ice Co., Indianapolis, Ind., on Aug. 10. Compressed air is furnished by a 14x14x18-in. compressor at 95 lb. pressure. The inlet temperature of the air showed 106 deg. F. The air discharge is directly from the top of the compressor and extends vertically several feet, then it is carried horizontally through several fittings and 35 ft. of pipe into the storage tank, as shown in the cut. Two distinct reports were heard in the tank when the top of the safety valve was blown off. The fracture occurred in the shell surrounding the seat, so that the disk was carried with the shell. Examination of the valve showed that it had been very hot and that failure was primarily due to the high temperature. The paint on the shell of the tank was blistered by the heat. About a year ago a similar explosion occurred with the same equipment. This time the spring in the safety valve was annealed so that it required replacing but apart from this no serious damage resulted.



Arragement of air receiver and piping

The explanation offered is that the oil used has too low a flash point and it accumulates in the top of the compressor until there is sufficient quantity to be blown out and it is discharged into the tank. The high temperature in the discharge pipe and the tank cause it to be vaporized and ignited, thus increasing the pressure and the safety valve operates the same as a poppet valve in a gas engine. The escaping burned gases, of very high temperature, weaken the brass case of the valve. Parts of the valve disk are also missing.

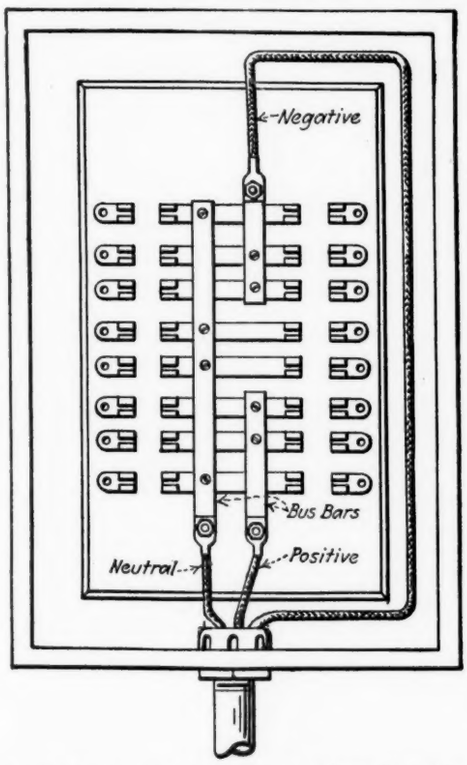
Recommendations are made that the compressor chamber be drained, drip pockets be placed on the air line, and that an air-compressor oil having a high flash point be used.

B. W. BISSELL.

Indianapolis, Ind.

Changing from Two-Wire to Three-Wire System

Not infrequently, the operating engineer or electrician is confronted with the problem of converting a two-wire system for operation on three-wire, as was the writer's recent experience. Power was being supplied to a panel board for lights and small motors operated at 115 volts. A change in the power supply system made it desirable to supply this load from a three-wire 115- to 230-volt system. At first changing over the entire wiring system along with the panel board was considered. However, after a little study of the problem the arrangement shown in the figure was decided upon.



Panel board changed from two- to three-wire by cutting one busbar and pulling in additional wire for neutral

As the voltage of the system was doubled, the current would be reduced by one-half for the same load. The panel board was supplied by two No. 1 wires pulled into a 1½-in. conduit. The first thought was to reduce the size of wire one-half, or from No. 1 to No. 4, so that the three wires might be pulled into the same conduit. After consulting a table of number and size of wires in conduits, it was found that three No. 1

wires could be pulled into the 1½-in. conduit. This was also verified by trial before pulling the old wire out.

With the same voltage drop in the system these wires gave the panel about double capacity as for the two-wire system. This additional capacity could be used at some future date should it ever become necessary. With the same load on the three wires, at 115 and 230 volts, as was originally carried by the two 115-volt wires, the voltage drop in the system would be one-half what it originally was, consequently the regulation of the system would be improved and the power loss in the feeder cable reduced to one-quarter of what it was for the two-wire system. Therefore this arrangement worked out very satisfactorily.

To make the two-wire panel board suitable for three-wire operation, one of the busbars was connected to the neutral and the other busbar was cut in half, one part being connected to one of the outside wires and the other section connected to the other wire, as in the figure.

A. A. FREDERICKS.

Philadelphia, Pa.

Unusually High CO_2 Obtained With Chain-Grate Stoker

To obtain 16 per cent CO_2 with not a trace of CO from a chain grate stoker appears to be somewhat unusual, but this is being done in the plant of the Springfield Gas & Electric Co., Springfield, Mo., with Kansas slack coal.

The boilers are 9,000 sq.ft. Stirling type, with 225

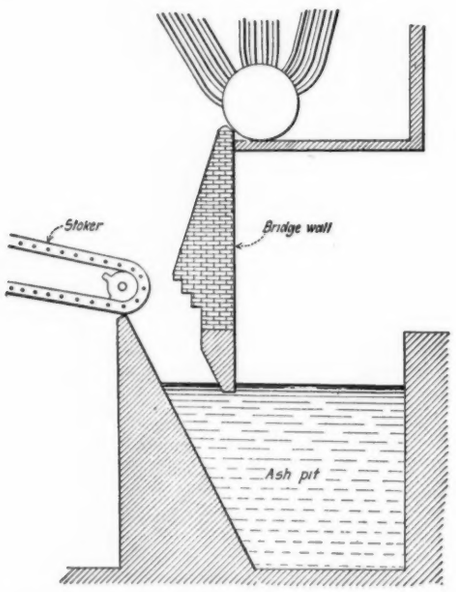


Fig. 1—Construction of ashpit provides effective air seal at rear of stoker

sq.ft. Stowe stokers, which are a modified form of chain-grate having special provision for retarding the movement of the fuel bed as it approaches the rear end. The boilers are set with the mud drum 10 ft. 6 in. above the grate surface, providing approximately 16 cu.ft. of furnace volume per square foot grate surface and 0.4 cu.ft. per square foot of boiler heating surface.

The ashpit is water sealed, ashes falling from the stoker into water, then striking a sloping wall and sliding into the main ashpit. The water surface of the pit is back of the boiler and accessible to a crane and grab bucket. This somewhat novel construction is comparatively inexpensive, 100 per cent effective as an air seal, and is fool-proof in operation.

When first put into operation these furnaces were equipped with all the necessary instruments including a

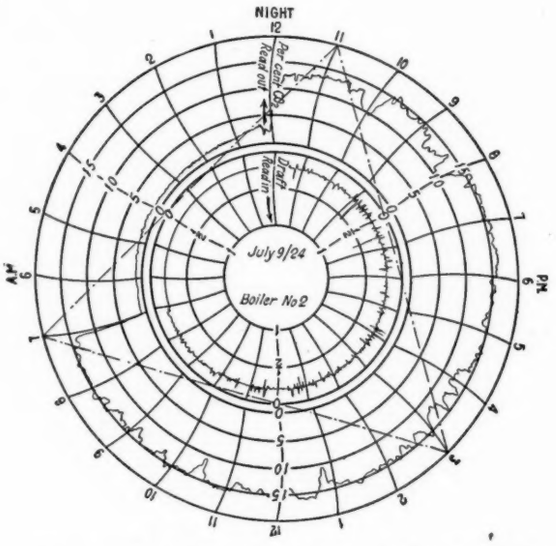


Fig. 2—Typical of the CO_2 readings obtained

recording CO_2 machine, and to start with, 14 per cent CO_2 was set as a temporary goal for the firemen. Some time passed before 14 per cent was obtained, but after much experimenting, when the proper thickness of fuel bed was determined and the proper relation of draft to load established, the goal was not only reached but passed, the firemen enthusiastically worked on up to 15 and 16 per cent. Right here it was thought that this was entirely too high so readings were taken with the Orsat for CO_2, oxygen, and CO. At 17 per cent CO_2, 0.2 per cent CO was observed, at anything under 17

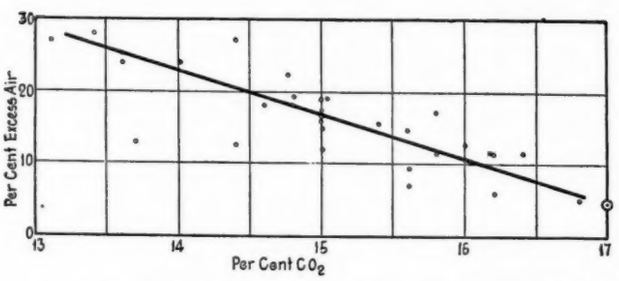


Fig. 3—CO_2 plotted against per cent excess air

per cent CO_2 any trace of CO has not yet been discovered, and the working limit for the firemen is now set at 16 per cent. A sample day's chart from the CO_2 machine is shown in Fig. 2. A series of Orsat readings taken at various intervals covering a period of two weeks have been plotted on the diagram Fig. 3. The CO_2 is plotted against per cent excess air as calculated from the Orsat readings for oxygen.

The chart from the CO_2 machine, Fig. 2, represents a banked fire from midnight to 7 a.m. and a load varying from 100 to 190 per cent boiler rating from 7 a.m. to midnight.

R. E. THOMPSON.

Springfield, Mo.

Comments from Readers

Boiler Feed-Water Treatment

I have been greatly interested in the discussions, in *Power* recently, on feed-water treatment.

For several years I had occasion, as a boiler inspector, to call on a large number of steam plants. It seems to me that the average operating engineer is only slightly interested as to what his feed water contains and as to just how hot he is pumping it into the boilers.

In one case in a plant of four horizontal return-tubular boilers a compound had been used for several years. This compound was prepared as a metal treatment and had practically no effect on the water. The result was a bad scale condition in the boilers and heater. Two of the quadruple-riveted butt-strap boilers had just been replaced after a service of only ten years. One other boiler had a new front ring just installed, and the fourth boiler had a new front ring installed two years previous.

The water-softening system described herein is applicable to the average plant: The Lebanon plant of the Indiana Condensed Milk Co., Lebanon, Ind., operates four 1,500-sq.ft. horizontal-tubular boilers, three on the line and one down. The boilers operate at 150 per cent of rating on the peak load. An open heater is used and a pump delivers water to the boilers at 212 deg. F. As the quantity of used steam to the heater varies considerably owing to a changing load and the steam used on the milk pans being about 50 per cent live steam, a spring-loaded regulating valve was installed in the 6-in. steam line to the heater. This valve works accurately and holds the heater pressure up to 2½ lb. The water head above the pump is 42 in., so in order to assist the pump in handling this hot water, a 48-in. standpipe was installed in the suction line close to the pump. The condensate was formerly returned to the boilers by means of two tilting traps. This was not very satisfactory.

Recently, a cold-process lime and soda-ash water softener was installed. This device consists of a large vertical open-end tank, with the tilting water buckets, chemical tank and filter at the top of the tank.

After operation was started, it was found impossible to reduce the hardness to 8 gr. per gal., by means of the lime and soda ash, on account of priming the boilers.

The trap which was located above the boilers was removed, and the lower trap was made to discharge into the top of the softener, entering a 24-in. cylinder which carries the hot condensate and the treated water to the bottom of the tank. It again rises to overflow into the filter.

In order to further reduce the hardness and prevent priming of the boilers, it was found that 9 lb. of Kerns water softener, with 8 lb. of soda ash and 40 lb. of lime, eliminated all priming. Water consumption was about 28,000 gal. per 24 hours. Then using phenolphthalien and methyl orange as the indicators, $Ph = 1.2$, $MC = 2$ as an average reading, with the standard soap solution test giving 1.3 gr. per gal. hardness. Raw water 20 gr. hardness. Tests are made at intervals during the day and a record is kept on special log sheet as shown herewith. The changes made in the water treatment have materially improved the boiler operation.

The results were as follows: The cold-process softener was changed to hot-process. Water of 1.3 gr. hardness was pumped regularly into the boilers at 212 deg. F. The chemical cost was $1.72 per day. Boilers are now cleaned each thirty days. The heater, formerly cleaned every two weeks, will now go to ninety days. The difference in fuel consumption due to change in water could not be ascertained on account of several other changes being made at the same time.

Lebanon, Ind. C. R. RAGSDALE.

Daily record of water treatment

PLANT Lebanon..... Date.....8-1-1924

Form 1166

Time		100 Ml. Sample		50 Ml. Sample	Ml. Soap Solution Minus 1	Remarks
		Ml. $\frac{N}{20}$ H_2SO_4		Ml. Standard Soap Solution		
A. M.	P. M.	Ph. Value	M O. Value		H Value*	
7		1.0	1.9	2.4	1.4	9 lb. 3c.
9		1.7	2.5	2.	1.	
	1	1.4	2.4	2.2	1.2	
	4	1.1	3.5	3.6	2.6	
						Chemical Cost
						$1.81

Charged solution tank at . . 8 A.M.	Total	Charged solution tank at . . P. M.	Total
	20 in. water		. . . . in. water
50 lb. soda ash per in. water	10 lb. soda ash	. . . . . lb. soda ash per in. water	. . . . lb. soda ash
2 lb. lime per in. water	40 lb. lime	. . . . . lb. lime per in. water	. . . . lb. lime
. . lb. caustic soda per in. water	. . . . lb. caustic soda	. . . . . lb. caustic soda per in. water	. . lb. caustic soda

*H equals the hardness in terms of grains calcium carbonate ($CaCO_3$) per U. S. gallon and is approximately correct between the limits of 1 to 7 grains per gallon.

Why Should the Smaller Pump Give Better Results?

I read with interest in the Aug. 26 issue F. L. Pakes's inquiry entitled "Why Should the Smaller Pump Give Better Results?"

From my experience with much smaller pumping units than described in this inquiry, it would appear to me that the trouble lay in the suction line of the 900-gal. pump, this not being large enough to take care of this larger pump, friction in the long suction line being a determining factor. I suggest that he try the pump near the supplying source, with as short a suction line as possible, and when in this position also try different sizes of intake hose, and I believe that these tests will show him where the trouble lies.

Branford, Conn. F. L. HAMMER.

Feeding Boilers Through the Blowoff

In the Aug. 26 issue R. K. Walsh, states that he objects to feeding "cold water" to a horizontal return-tubular boiler through the blowoff line, but if the water is 180 deg. F. or above he considers it good practice.

Water at room temperature is usually around 80 deg. and with a steam pressure of 100 lb. gage the temperature of the water in the boiler would be 387.5 deg. The difference would be 257.5 deg., while if the feed-water temperature was raised to 180 deg., the difference would still be 157.5 deg., which is enough to cause considerable uneven expansion in the boiler plates.

It is my opinion that feed water should be introduced in this type of boiler at some point where it cannot come in direct contact with the boiler plates.

Shamrock, Okla. H. T. SMITH.

Sensible Heat Loss in Refuse

E. Ogur, in an article on page 287 of the Aug. 19 issue, states that under the most favorable conditions the loss due to the sensible heat of the refuse from the furnace of a steam boiler is not less than 1.5 per cent.

I am of the opinion that, although there may be cases where it is this large, the loss due to the sensible heat of the refuse is less than one per cent in the greater number of power stations. In figuring out an example, Mr. Ogur assumes that the temperature of the refuse leaving the furnace is 2,400 deg. F. Although the temperature of the furnace is frequently higher than this, it does not follow that all the heat below that value is wasted. In an underfeed stoker storage space is provided in a clinker pit or a clinker plate to permit a slow downward motion of the refuse as it is being burned out. With good operation the greater part of it is cooled to a low temperature in preheating the air passing up to the surface of the fuel bed where the percentage of the coke is greater and the refuse is practically all incandescent. The average temperature of the refuse when it reaches the point when its heat can no longer be transferred to the air passing into the furnace is believed to be less than 1,000 deg. F. in practically all well-operated underfeed stokers. The minimum temperature shown in Mr. Ogur's curves is 1,000 deg. With the assumed conditions used in his examples the loss with 1,000-deg. refuse temperature would be about 0.5 per cent.

Mr. Ogur's curves are valuable in that they show how great the loss may be when the operation is poor. With a very high percentage of combustible in the refuse its temperature, as well as weight, will be increased, causing the loss due to sensible heat to be considerable. Even with a small amount of combustible in the refuse the sensible heat loss may be large when the stokers are not properly operated.

In an effort to prevent clinker formations, it is the practice in some plants to adjust the clinker plates so that the refuse, while still incandescent, is continually dropping over the edge of the plate. With this method of operation the losses will be of the magnitude indicated by Mr. Ogur's example. To prevent such losses, the clinker plate should be brought near enough to the back or bridge wall to cause the refuse to seal over the space between the plate and wall. This will cause it to accumulate to some depth and permit its being cooled before it is discharged to the ashpit.

Springdale, Pa. E. G. SUTTON.

Why Does the Temperature of the Furnace Wall Increase After Fires Are Extinguished?

The inquiry of M. S. Gerend in the June 17 and Aug. 12 issues as to the cause of the rise in temperature of the furnace walls after fires are out, recalls an incident which brought out quite forcibly the extent to which a furnace wall will radiate heat.

It was customary to change boilers every six weeks, and usually the change was made on Sunday. A small turbine-driven centrifugal pump was used in connection with a hot-water system of heating, and when changing boilers I let the fire die out and allowed the turbine to run and use up the steam in the boiler to be dropped, until the pressure had been reduced to about 50 lb. This routine was completed in a few hours, and the stack damper, furnace and ashpit doors were then closed. Steam was used for heating purposes throughout the night, which made it necessary to run the newly fired boiler up to capacity.

In relieveing the fireman Monday morning, I was surprised to find the steam gage on the supposedly "dead" boiler registering 85 lb., which was within 5 lb. of blowing-off pressure.

As there were two stop valves between each boiler and steam header and I was certain that these were tight, I concluded the rise in pressure to be due directly to radiation through the dividing wall between the boilers, aided by the heat retained in the brickwork of the "dropped" boiler.

To satisfy my curiosity and prove that I was right in my conclusion as to "heat radiation," I opened a furnace door and the stack damper a small amount and within a half hour the pressure started to fall.

Now referring to Mr. Gerend's article; he does not give the steam pressure carried on the boilers, but it seems to me that the temperature of the water in the boilers would have considerable bearing on the length of time the furnace walls maintain a terminal temperature, and as to the "gradual rise" he speaks of, there is no doubt in my mind that the heat contained in the boiler, assisted by the thermal storage of the brickwork, is the direct cause of the rise in temperature of the furnace walls. LEROY BLAKE.

Worcester, Mass.

Broken Wires in Elevator Cables

In the Aug. 5 issue of *Power* there appeared an article on elevator cables, which states that when six wires are broken in a strand, it should be removed. This statement is not clear, because the six breaks might be in six inches of the cable or it might be in a 100-ft. length. C. B. Garrison, my chief engineer, states that the wires break faster the first six months than they do after that time, due perhaps to the unevenness in their winding or making. We have had six breaks in a 24 in. length of cable, and the cable made 25,000 miles before it was removed.

In the Sept. 18 and Nov. 13, 1923, issues of *Power* there appeared a complete article on elevator cables by the author and Mr. Garrison, the data for which covered a period of ten years of experimenting. These tests were conducted by the University of Cincinnati.

Cincinnati, Ohio. M. W. McINTYRE, Bldg. Mgr.,
Union Central Life Insurance Building.

[The statement referred to by Mr. McIntyre should have read: "As a general rule hoisting and drum counterweight cables should be replaced when six or more broken wires occur in one lay of any one strand." —Editor.]

Boiler Inspectors and Inspections

The article in the Aug. 12 issue by C. W. Olander, entitled "Boiler Inspectors and Inspection," contains several passages that are open to discussion and perhaps also a little constructive criticism.

In the first place, the qualifications required of a candidate before being allowed to sit for a boiler inspector's commission should entirely eliminate the "monkey wrench engineer," and bearing this in mind I suggest that a little more originality be introduced into the examination conducted by the National Board of Boiler and Pressure Vessel Inspectors.

My reasons for this suggestion are, that after a careful perusal of the questions, dating back for a number of examinations, I find there is a decided similarity, and instead of the examination being a test of intelligence and reasoning power it merely resolves itself into a test of memory.

When one stops to consider the nature of a boiler inspector's work and the moral responsibilities entailed, it becomes evident that the five years' practical experience demanded by the board is fully justified.

Modern and progressive casualty insurance companies, however, are becoming more careful of the type of men they employ, and generally stipulate that applicants for the position of boiler inspector shall, in addition to having a good technical education, be conversant with modern power-plant equipment; and as the business of an insurance company may be marred by the inefficiency of its engineering inspection service, it naturally follows that they are not desirous of employing the services of the "monkey wrench engineer" type.

I do not entirely agree with Mr. Olander when he suggests that young inspectors should make out a data report on every boiler they inspect, as in my estimation this procedure is a waste of time, assuming, of course, that the preliminary inspection has already been made. He should be given the opportunity to make preliminary inspections of new installations, make all the necessary calculations to insure that the boiler conforms to the code requirements, and compute the efficiencies, submitting the results of his investigations to his supervisor, who could then check him up from the manufacturer's data sheet.

A boiler inspector often has to assume the rôle of consulting engineer, and it is a desirable accomplishment if he can discuss intelligently with the chief engineer of a plant such problems as the treatment of feed water, elimination of corrosion and deposit of scale, the correct design of furnace arches and bridges in order to get the highest efficiency out of the particular type of fuel used; and it is not improbable that he may be asked for his advice as to the most suitable type of equipment in the event of a new installation being contemplated. In this way he can gain the confidence of the engineering staff and also the management, so that his visits will constitute an asset to the plant rather than a necessary evil.

The practice of putting too much reliance on information received from employees at the plant under inspection is to be deplored, as a boiler inspector, if he has made a thorough and conscientious inspection, can usually deduce by his own powers of observation if the equipment is being operated properly or abused. I do not mean to imply by this that the opinions of the operators in the plant should be ignored, but when an inspector has to depend too much on that source for his information a loss of prestige may ensue.

Lastly, referring to the requirement put forward by Mr. Olander, "A whole lot of common sense," might I suggest that a man who is entitled to call himself an engineer in the true sense of the word—as assuredly a good boiler inspector should be—is already in possession of this desirable commodity.

Detroit, Mich. ROBERT G. MELROSE,
Ocean Accident & Guarantee Corp.

Piston Rings and Feed Piping

The letters by R. Manly Orr and Frederick Pakes in the Aug. 12 issue of *Power* bring back to mind two experiences of a similar character I had several years ago in an ice plant containing two boilers and an ammonia compressor with a steam cylinder 18 in. in diameter. When I took charge, both boilers were required to keep steam. It was evident that there was something wrong in the cylinder, and upon taking out the piston there was no sign of a ring. The piston, which had only one groove on it, was not broken anywhere, and it always has been a mystery where the ring went to. After a new ring was put on, it was easy to pull the load with one boiler.

With Mr. Pakes' feed line as it was, it is a wonder they could keep the feed line on the boilers, as with the water discharging into dry steam, violent water hammer should have resulted.

In my case the feed line entered the boiler at the top with a long threaded nipple screwing through the shell plate and a coupling inside the boiler with a pipe long enough to reach nearly to the bottom of the shell going down through the center of the tubes. One day the feed line began to jerk and the check valve hammered as if it would upset the piping. The boiler was shut down and when cool it was found that the discharge pipe had become unscrewed from the nipple and was lying on the bottom of the shell. After the pipe was put back in place, the noise and vibration stopped.

Elwood, Ind. WALTER CARR.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Rust Spots on Exhaust-Valve Seats

We are troubled with pitting of the exhaust-valve seats of a non-releasing Corliss-type valve engine with double-ported exhaust valves. This pitting occurs along the working edge of the outside or higher port and extends back for the full lap of the valve. The valves are not affected except from being cut by rubbing on the roughened surfaces which have the appearance of being etched to a depth of $\frac{1}{32}$ in. This engine operates non-condensing with 100 lb. steam pressure and runs about 50 hours a week. What would cause such corrosion? *F. A. C.*

Undoubtedly, the rust is a continuance of corrosion that had its beginning from deposit of moisture before the engine was put in service. Such rust spots formed on parts of newly machined surfaces of cast iron frequently continue long after the rest of the surfaces have become worn smooth and bright. The corrosion, assisted by abrasion, appears to sink into the iron as fast or faster than the rest of the surface is worn away.

Refrigeration from Brine Coil

We have a calcium chloride brine coil in an ice box operating under the following conditions:

Average incoming temperature of brine, deg. F.	23.
Average outgoing temperature of brine, deg. F.	24.75
Range in brine temperature, deg. F.	1.75
Cu.ft. of brine passing through coils in 24 hours	857.
Specific gravity of brine	1.16
Specific heat of brine	0.83

What amount of refrigeration is produced? W.P.

The heat absorbed per 24 hours would be given by the formula,

$$(1)\quad H = W(T_2 - T_1)c,$$

in which

H = B.t.u. absorbed per 24 hours;
W = Weight of brine passing through the coils in 24 hours;
T_2 = Final temperature of the brine;
T_1 = Initial temperature of the brine;
c = Specific heat of the brine.

Since the specific gravity of the brine is 1.16, taking the weight of 1 cu.ft. of water as 62.3 lb., would make the weight per cubic foot equal to $1.16 \times 62.3 = 72.268$ lb., and having 857 cu.ft. passing through the coils in 24 hours, the value of W in the formula would be $857 \times 72.268 = 61{,}934$ lb. As the brine has a final temperature of 24.75 deg. F. and an initial temperature of 23 deg. F., the term $(T_2 - T_1)$ would be equal to $24.75 - 23 = 1.75$ deg. F., and as c is 0.83, by substitution, the formula becomes

$H = 61{,}934 \times 1.75 \times 0.83 = 89{,}959$ B.t.u. per 24 hr.

The unit of refrigeration is the number of B.t.u. that must be abstracted from one ton of water at 32 deg. F. to produce one ton (2,000 lb.) of ice of the same temperature. Since the latent heat of ice is 144 B.t.u.—that is, since 144 B.t.u. must be withdrawn from one pound of water at 32 deg. F. to produce one pound of ice at 32 deg. F.—the unit of refrigeration called one ton of refrigeration is equal to the removal of $2{,}000 \times 144 = 288{,}000$ B.t.u. Hence for removal of 89,959 B.t.u. in 24 hours the refrigeration produced in that time is $89{,}959 \div 288{,}000 = 0.31$ ton.

Utilization of Exhaust in Laundry

What would be the best method of utilizing the heat of exhaust steam of a non-condensing engine, pumps and other steam-driven machinery of a large laundry, for heating water used for boiler and washing in place of depending entirely on live steam for those purposes? *P. A. C.*

The best method of utilizing the exhaust would be by use of a closed exhaust steam heater through which the water can be forced by the regular supply pressure. The heater should be three to four times the size usually employed for heating only as much boiler-feed water as would be required for generation of steam used by the engines and pumps. Although the heater may not be able to raise all water required to the boiling point, the desired temperature can be obtained by injection of live steam where the hot water is required. If the temperature of the present cold-water supply is 50 deg. F., each pound of water raised to the boiling point by live steam requires $212 - 50 = 162$ B.t.u., and if by means of a closed heater the water is raised to only 150 deg. F. the saving from use of the heater would be 50 to 60 per cent of the fuel now required for heating the water only by live steam.

Why Six-Phase Rotary Converters Are Used

Why are rotary converters generally made with six collector rings on the alternating-current side with their supply of alternating current for running from three-phase lines, which is then stepped down by transformers to six-phase and at a lower pressure? This means three transformers for each converter and a lot of extra wiring. Why are not the converters three phase, or what is the advantage in having six phases over three phases? *R. G. S.*

Rotary converters generally are made six-phase instead of three-phase, because the six-phase machine has a higher efficiency than the three-phase machine, and with machines of given dimensions the six-phase machine will have a greater capacity than the three-phase machine. Twelve-phase converters have been suggested, but the advantage of this type of machine over the

six-phase has not been sufficient to warrant the added complication.

It may seem that if three-phase converters were used, the transformers could be dispensed with. This, however, is not true since the voltage on the collector rings of a rotary converter is not a standard value, and transformers would have to be used in the case of a three-phase machine just as it would for a six-phase machine.

On the collector rings of a single-phase or a two-phase rotary converter the alternating voltage is approximately seven-tenths that of the direct-current voltage on the commutator. For a three-phase rotary converter or a six-phase double-delta-connected rotary converter the voltage on the collector rings is approximately six-tenths that on the commutator. For a six-phase diametrically connected rotary converter the voltage on the slip rings is approximately seven-tenths that of the direct-current voltage. Therefore, to obtain 220 voltage on the direct-current side of a rotary converter the voltage on the alternating-current side will have to be approximately $220 \times 0.7 = 154$ or $220 \times 0.6 = 132$ volts, depending on the number of phases in the machine, neither one of which is standard for alternating-current circuits.

Fuel Saved in Refrigerating Plant from Use of Cooling Water of Lower Temperature

We have two double-acting vertical ammonia compressors each 10 *in. in diameter by* 30*-in. stroke running* 65 *r.p.m., operating under a back pressure of* 20 *lb. gage in the suction line and average pressure on the compressors* 185 *lb. per sq.in. The compressors are driven by a horizontal non-condensing Corliss engine with cylinder* 20 *in. in diameter in which the m.e.p. is* 55 *lb. per sq.in. The temperature of cooling water going over the ammonia condensers is* 80 *deg. F. How is it determined what the saving of fuel would be from the use of cooling water having a temperature of* 54 *deg. F.?* W. W. H.

The best way of solving this problem is by the use of a Mollier heat chart. It is assumed that the liquid ammonia is at 96 deg. F., which is the boiling temperature at 200 lb. absolute (185 lb. gage). In this condition each pound of ammonia has in it 150 B.t.u. measured from —40 deg. F. On evaporating at 20 lb. gage (35 lb. abs.) each pound of dry saturated ammonia vapor contains 614 B.t.u., or 464 B.t.u. have been absorbed from the coils. After compression from 35 lb. absolute to 200 lb. each pound contains 722 B.t.u., or 108 B.t.u. of work has been done for each 464 B.t.u. of refrigeration, or for each B.t.u. of refrigeration 0.23 of B.t.u. work is required.

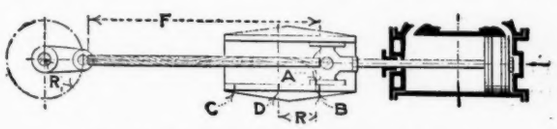
If the cooling water is at 54 deg. instead of 80 deg. and the same temperature difference of 16 deg. between the water and ammonia in the condenser is assumed, the liquefying temperature of the ammonia in the condenser will be 70 deg. which corresponds to 127 lb. per sq.in. absolute.

A pound of liquid ammonia at 127 lb. contains 120 B.t.u. After going through the expansion valve and evaporating at 35 lb. absolute, it contains 614 B.t.u., or 494 B.t.u. has been picked up from the coils. After compression, back to a discharge pressure of 125 lb., each lb. of ammonia vapor contains 691 B.t.u. In other words, $691 - 614 = 77$ B.t.u. has been added by compression to do 494 B.t.u. of refrigeration. This means that each B.t.u. of refrigeration requires 0.15 B.t.u. of work. The work required per ton of refrigeration with the low-temperature water will be $\frac{1}{2}\frac{5}{3}$ of that required with the high-temperature water. The amount of steam saved per hour depends upon the efficiency of the engine at the new cutoff, but under new circumstances the steam consumption should be about $\frac{1}{2}\frac{5}{3}$ of that required under the high-temperature water.

Determining Length for Connecting Rod

How can the proper length required for an engine connecting rod be measured? W. L. G.

The length of a connecting rod is understood to be the distance from the center of the bore for the crankpin to the center of the bore for the crosshead pin, when the brasses are keyed up in their position for running the engine. For purposes of this measurement the length may be considered to be the same as the distance from the center of the crankpin to the center of the crosshead pin when the brasses are keyed up tight on the pins. For determining the length required, disconnect the connecting rod from the crosshead, see that the piston rod is firmly set in the piston, and set the piston rod in the crosshead as nearly as possible in the center of its adjustment without turning the piston to a different position in the bore of the cylinder, as that would bring together new wearing surfaces between the piston and cylinder. Then with the cylinder head in place, slacken the piston-rod packing and make a mark on the crosshead shoe as indicated in the figure at *A*



Finding length for connecting rod

and a corresponding mark *B* on the guide when the crosshead is moved as far as it will go with the piston pressed hard against the cylinder head. Make another mark *C* on the guide to correspond with the mark *A* when the crosshead is moved as far as it will go with the piston pressed hard against the crank end of the cylinder. Next locate a point *D* on the guide midway between marks *B* and *C* to indicate where the mark *A* should be at mid-stroke with a connecting rod of proper length to give the same amount of piston travel clearance at each end of the cylinder. Then move the crosshead to a position that will make the distance *R* equal to one-half stroke, which would be equal to R_1, the radius of the circle described by the crankpin, or the value of *R* may be found by taking one-half of the travel over the guides by any point like *A* on the crosshead for a complete revolution of the crankshaft when the crankpin and crosshead are connected by any length of connecting rod. Then with the crank on the head-end dead center the distance center to center of crank and crosshead pins will be the length of connecting rod for obtaining equal piston-travel clearance. The distance between the pins can be determined by cutting a rod whose length *F* reaches from pin to pin, and the required distance, center to center of pins will be the length of the rod plus half the sum of the diameters of the pins.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Instruments as an Aid to Boiler Operation

THE idea still lingers in the popular mind that the operation of boilers is a task requiring brawn but no brains. Nothing could be farther from the truth. Of course, boilers can be kept going after a fashion without the exercise of much intelligence, but operation on a basis of real economy is a task worthy of any engineer's ability.

First comes a problem in practical economics—that of selecting the kind and grade of fuel that will produce a thousand pounds of steam at the lowest total cost. This involves not only the cost of the fuel on the B.t.u. basis, but also the efficiency with which it can be burned, the capacity obtainable with it (where the plant is pushed for capacity), the effect of the type of fuel on ash-handling costs, etc.

Then there is a problem in transportation—getting the coal to the boiler in the least expensive manner. The next problem is chemical, the bringing together of two elements (carbon and oxygen) in such a manner and under such conditions that the two combine and release heat at the desired rate. The complete release of this heat—that is, the prevention of combustible in the ashes and carbon monoxide (CO) at the uptake—are problems auxiliary to this, as is the matter of releasing the heat in such a manner that it is concentrated in the minimum volume of gas.

Another set of problems is bound up with the transfer of the heat in the gas to water or steam. This last involves the flow of heat from gases to solids and the simpler problem of its flow from metal to water and vapor. It also involves the mechanics of soot and scale removal and the chemistry of water softening.

Guesswork Has No Place

Finally there is the mechanical problem involved in the removal of ash at the minimum cost, the economic and mechanical problem of driving the auxiliaries in the most effective manner and the thermal-economic problem of preventing loss of heat by leakage of steam and hot water and by radiation from heated surfaces.

Being strictly a scientific matter from start to finish, boiler-room operation cannot be properly handled to the basis of rule of thumb, "hunch," or even trained but unassisted observation. For one thing, how is the engineer to know, without instruments, whether he is running the plant well or not? Relative data as to the tons of coal burned yearly do not tell the whole story. The total steam consumption is affected by variations in the steam demand.

It is of great importance that means be provided for a day-by-day (and if possible moment-by-moment) record of the water evaporated and the coal consumed. Every well planned boiler room is provided with reliable meters for measuring the feed water to the boilers and with scales of some sort for weighing the coal used. Steam meters give a check on the water-meter readings and also—when placed on individual boilers—eliminate the chance of certain boilers loafing while others are overloaded.

With coal and water (and steam) meters showing the over-all performance of a boiler plant, other meters and instruments are required to check up on the various losses as they occur. The coal and water measurements merely show how good operation is. They do not tell where the trouble lies when the performance is not up to the capabilities of the plant.

The principal apparatus required for detecting and correcting losses are draft gages, CO_2 and CO recorders, Orsats, thermometers, pyrometers and equipment for ash analysis.

Most important of all the losses in steam boilers is the so-called dry-gas loss, which is occasioned by the fact that the huge quantities of flue gas leaving the boiler are above the boiler-room temperature.

78 Tons of Hot Gas Wasted per Hour

Theoretically, it takes ten to eleven tons of air to burn one ton of coal. Practically, the air runs from 13 to 25 tons. The former is possible only in the exceptional plant, while the latter (representing very bad operation) is frequently found in small plants where the engineers are not concerned with good combustion. This amount of air per pound of coal corresponds approximately to about 7 per cent CO_2. Since the coal goes up the chimney with the air, this would mean throwing about 26 tons of hot gases to waste for every ton of coal fired. A small plant consuming three tons of coal per hour would send to waste 78 tons of hot gases in the same period. Imagine the coal consumed by a hot-air heating system delivering 78 tons of air per hour at 500 deg., and you get a rough picture of the coal wasted in this plant. Not all this waste can be prevented, but it can be greatly reduced in most plants.

The secret is not, as it might seem at first, to cut down the draft or the flow of air through the fuel bed, but rather to insure that the air used is actively engaged in the combustion process. This requires a smooth even fire, good mixing of the gases in a hot combustion chamber, and the elimination of the air leaks into the setting where it does not assist combustion.

The CO_2 recorder and the Orsat give a sure indication of excess air—air that does not enter into combustion. Any large difference between the CO_2 in the first pass and that in the breeching proves the existence of serious air leaks in the setting. These should be ferreted with a candle and plugged. If there is still serious air leakage, it may be due to air infiltration through the pores of the brickwork. This can be largely eliminated by coating the boiler with one of the impervious preparations on the market for the purpose.

Where Draft Gages Come In

Where forced draft is provided, still further reduction in the air leakage into the setting can be accomplished by the use of a practically balanced draft with only a slight suction over the fire. To insure this condition is one of the chief uses of the draft gage. Draft gages reading the drop through the fuel bed, and through the boiler setting, are also useful, the latter giving an idea of the rate of combustion in terms of gas flow and the former indicating the fuel-bed resistance. Clogged fires or fires full of holes are immediately detected with the draft gage.

With the air leaks plugged and balanced draft the CO_2 will rise and the flue temperature go down. The CO_2 should generally be raised close to the point (as indicated by the Orsat or CO recorder) where combustion is not complete.

Even with the excess air properly adjusted, indicating or recording thermometers may show too high an uptake temperature. This is notice that the baffles are leaky or the boiler dirty. These conditions can then be remedied.

Efficient boiler operation is facilitated by the use of a type of meter combining readings of air flow and steam flow on a single chart. The best combination having been found by trial, these indications should vary together. An increase in steam flow will be practically in proportion to the increase in actual fuel consumption which in turn should be proportional to the increase in air flow. When the two indications pull apart appreciably it is evidence that something is wrong with the operation of the boiler.

With a few simple pieces of apparatus the ash can be tested for the percentage of combustible matter. If this is high, it can be reduced by giving more attention to the operation of the stoker or to the methods of firing and cleaning of fires in the case of hand-fired boilers.

While instruments are essential for efficient boiler operation, the point should be stressed that they are useless if not kept in good condition or if constant attention is not given to their readings.

Forty-Second Annual Convention N.A.S.E. Held at Grand Rapids

WITH an official delegation approximating 350, a large registration of visiting engineers and the second largest exhibit in the history of the organization, the annual convention of the National Association of Stationary Engineers, held in Grand Rapids from Sept. 8 to 12, was a decided success. Much credit is due the convention committee and President R. H. Holbrook, who conducted the business sessions with dispatch, giving time for the most extended presentation of technical papers ever attempted. Committee and official reports were given in abstract, and education, the primary function of the Association, assumed its true rôle in the convention proceedings.

National Secretary Fred W. Raven reported ten new associations in the last year. Forty associations have been flag winners, with increases in membership ranging from 10 to 68. Annual reports of subordinate associations show an active membership of 19,968. There is a tendency toward the combination of associations in large cities. In New York City four locals are to unite soon and this movement extends to other large centers.

Financial conditions are flourishing. National Treasurer Samuel B. Forse gave receipts for the year of $42,294 which with the balance on deposit made the total available funds $68,162.32. The total disbursements were $43,963.62 leaving a balance of $24,198.70 on Aug. 31, 1924.

Activities started on Tuesday with the usual addresses of welcome and responses. Dean G. W. Bissell, of Michigan Agricultural College, reviewed the development of steam power and the improved facilities for obtaining a more thorough engineering education. Schools and colleges were more ready to co-operate and help all who were ambitious to advance, on the basis that education was good and more of it better.

President R. H. Holbrook reviewed the engineering features of the year, with statistics on power production and fuels available. In association work he emphasized the importance of selecting good officers and summarized committee work. More educational work was favored, even to the extent of going into the per capita fund if necessary. The constitution needed to be shorter and plainer. Next year would be an appropriate time to discuss and rewrite it. A suitable memorial for John Lane was proposed, the suggestion carrying with it an appropriation of $1,000, with a similar sum to be set aside for the next four or five years to provide an income to assure some of the younger aspirants of the association a college education.

Labor and Horsepower

On Tuesday evening the delegates listened to an illustrated lecture by C. M. Ripley, of the General Electric Co., showing how increased production, increased wages and better economic conditions accompany increased application of power per wage earner. The speaker drew a striking contrast between England and the United States, showing by slides the comparative horsepower per 1,000 workers and the value of the production per wage earner per year for a number of representative industries in the two countries. American workers in factories and mines produce two to three times as much per man per year as the British because of the greater horsepower per worker employed — nearly 3½ times. This low production per worker has been responsible for the low wages in England, while the reverse has been a determining factor in the higher wages paid in the United States. England suffers not from over-production but under-consumption, and under-consumption is due to under-production.

Looking to the cause for this, Mr. Ripley explained that many British employers are too conservative, while the more progressive ones have been prevented from making greater use of labor-saving machinery by the attitude of the workers themselves. On the other hand, American labor sees a friend in machinery as is evidenced by a quotation from Samuel Gompers, who says:

"Whenever men are cheap no machinery is used in the industry. It is only when men are dear and wages are high that machinery is brought in."

Tracing this condition in its relation to the production of power, Mr. Ripley quoted figures from an address by W. H. Patchell, president of the British Institution of Mechanical Engineers, showing that the kilowatt-hours sold per capita per year, as an average for seventeen English central stations, was 191 as against 547 for an average of eleven representatives stations in the United States.

The lecture was supplemented by several motion-picture reels emphasizing the idea.

Power Development Outlined by Fred R. Low

The remarkable evolution that has taken place since the founding of the N.A.S.E. in 1882, was outlined by Fred. R. Low, editor in chief of *Power* and president of the A.S.M.E., in a paper entitled "Twoscore Years of Power Development." The engineer, he said, whose professional life covered this entire period has seen the "steam-driven pinwheel" develop into the smooth-running and efficient steam turbine. He has seen the birth of the Diesel engine, still the most efficient of prime movers. He has watched boiler-room practice develop from the days of the hand-fired low-set and smoky cylindrical boiler to that of the stoker-fired high-pressure water-tube boiler with power-driven auxiliaries, recording instruments, and now—at last—complete automatic boiler-room control. Finally, he has seen the operating engineer himself develop from an engine driver with an oil can as his insignia to an engineering executive.

Having summed up the outstanding developments, Mr. Low proceeded, with the aid of lantern slides, to illustrate a few of these changes. Harking back to 1882, the engineer's pride in his Corliss engine was contrasted with the lowly position of the boiler room. The engineer took pride in the indicator room with which he tested the valve adjustments of and measured the load upon his engine, but he had no corresponding apparatus for the boiler room, nothing much but a pressure gage and water column.

The typical horizontal-return-tubular boiler of that period, said Mr. Low, was set much too close to the fire, carried a steam pressure of 70-80 lb. and evaporated perhaps three pounds of water per square foot per hour, with natural draft. Fairly good boiler efficiencies were obtained on occasional tests, but the day in and day out boiler efficiency was low in the average plant.

The better engines of the day, at least on the recorded tests, were surprisingly economical, considering the low pressures in vogue. Average steam rates for Corliss engines stood around 30 lb. per i. hp.-hour non-condensing and 20 lb. condensing. According to Mr. Low, builders of unaflow engines in moderate sizes are now claiming non-condensing steam consumptions of 13.7 to 14.5 lb. per i. hp., with Rankine efficiencies up to 90 per cent. For condensing operation steam rates of 10.2 lb. are claimed with a corresponding Rankine efficiency of 76 per cent.

In boiler plants the biggest change has been not so much a betterment of efficiency records (in 1880 Professor Unwin reported a test efficiency of 80 per cent for a Lancashire boiler), but rather in an enormous increase of capacity per square foot of heating surface. The modern large boiler, said Mr. Low, evaporates from three to four times as much water per square foot of heating surface as would those of 1882. Single units have been built to evaporate 150 tons of water per hour.

As pressures and capacity demands continued to go up, it became difficult to provide room enough in the low-pressure cylinder for the highly expanded steam, and then the turbine came along and pushed the big steam engine off the stage. In the small and medium sizes the reciprocating engine has recently staged a comeback due, in the main, to the introduction around 1910 of the unaflow engine, which prevents the losses from cylinder condensation without the necessity of compounding.

After calling attention to the fact that even today the average boiler room in America and England operates around 56 per cent efficiency, a figure that could be greatly improved by intelligent operation, the speaker said that the representative modern boiler rooms equipped with mechanical

equipment for handling coal and ashes, mechanical stokers, well-designed boilers and settings, recording and indicating instruments, etc., showed a remarkable change in the attitude of engineers and owners toward this part of the power plant.

Mr. Low's remarks on the central station, as affecting the future of the operating engineer, may be summed up as follows: Where power can be supplied by central stations more economically than it can be made locally the engineer should not oppose its purchase. On the other hand, aggressive salesmanship has sometimes resulted in the shutting down of plants that should have been kept running. Making due allowances for a certain natural tendency toward centralization, three fields will be open to the operating engineer of the future: First, isolated plants so situated that the central stations cannot compete; second, industrial plants that will purchase power but require the service of an engineer for the operation of boilers, pumps, elevators, heating systems, etc.; finally, the central stations themselves will offer a wonderful opportunity for a limited number of high-grade operating engineers.

Applications of Pulverized Fuel

A paper by Frederick A. Schaffler, manager, power department, Fuller Engineering Co., was presented by H. A. Reichenbach, of the Fuller-Lehigh Co., which reviewed the growth in the use of pulverized coal and showed a map giving the location of 220 such plants. Last year fifteen million tons of coal was pulverized, and plants are being built that will increase this figure 15 per cent. The speaker cited the advantages of powdered fuel as the convenience of being able to utilize efficiently variable grades of fuel and to operate the boiler plant at sustained overloads. Figures given showed that furnace volumes for burning powdered fuel are based on seven to ten feet per second gas velocity to prevent erosion of brick work. This is equivalent to one and three-quarters to two cubic feet of furnace volume per ten square feet of heating surface. It was reported that firebricks are being developed for operation at 3,400 deg. F., which will permit a 25 per cent increase in gas velocity. The speaker described the Fuller-Kinyon pulverized-coal system, showed views of typical plants and gave test figures for such installations.

The Diesel Engine as a Prime Mover

In a discussion on The Diesel Engine as a Prime Mover, L. H. Morrison, assistant Editor of *Power*, pointed out that records of power plants show that fuel and labor constitute 80 per cent of the total operating costs. In view of this the increases in coal prices and in labor rates since 1900 indicate that the cost of generation has and will continue to rise in spite of the construction of more efficient machines. Charts were shown giving the steam consumption of steam turbines and unaflow engines, attention being called to the marked difference in the consumption per kilowatt-hour of a 1,000-kw. and a 50,000-kw. unit. Since the large plant, particularly the larger central stations, can obtain a fuel consumption much lower than possible in small plants, such as are in isolated factories, the increase in fuel prices tends to make the difference between the central station and factory plant costs still more marked.

For this reason the speaker felt that engineers who heretofore have been interested almost exclusively in steam prime movers should investigate the possibilities of oil-engine drive, since this type of engine does possess a high thermal efficiency and will produce power at a very low cost, by reason of its high thermal efficiency and its low attendance charges. Charts were shown giving the fuel consumption of the Diesel compared to steam turbines, emphasis being placed on the fact that a small Diesel has practically the same efficiency as a 12,000-hp. unit, and that this is 40 per cent higher than that of the largest steam plant.

Records of 21 large central stations indicated that the average generating cost was 7.9 mills per kilowatt-hour with coal ranging from $2.20 to $6.80 per ton, these records including plants of 100,000 kw. capacity. Numerous Diesel plants, the speaker claimed, are bettering these records, citation being made of the Carthage, Mo., municipal plant, where the total operating cost is but 6.7 mills.

To make a direct comparison data were given showing the fuel consumption of a Diesel and a condensing steam turbine in the power house of a flour mill. The turbine used four times the oil fuel consumption of the Diesel and a 20 per cent variation in load increased the consumption of the turbine by 27 per cent, while the Diesel on a 50 per cent load variation showed but a 3 per cent fuel increase. The record of the oil engine for sustained efficiency was stressed, data given showing that an engine built in 1904 had the same efficiency as a modern unit and a unit built in 1907 after 10 years of operation giving a fuel consumption only 5 per cent above its original record.

Since 1912, when the original patents expired, many firms have taken up Diesel construction, at present there being 30 such builders. Typical present-day engines were shown, ranging from a 30-hp. solid-injection engine to a 4,000-hp. double-acting two-stroke-cycle air-injection Diesel.

Mention was made of the suitability of oil engines as stand-by units for hydro-electric plants. The speaker believed that in many cases steam units, which are cheaper in first cost, had a higher operation cost and that Diesels were preferable. While it was conceded that as a general rule the necessity of process steam indicated the choice of steam engines, nevertheless there were plants where the Diesel had proved economical even though low-pressure boilers were used for the process steam.

The Diesel Engine Power Plant

The paper by Louis R. Ford on The Diesel Engine was devoted in the main to explanations of the two- and four-stroke-cycle principles, together with practical suggestions as to the proper operating procedure.

The speaker outlined the difficulties most frequently encountered in the operation of the oil engine, laying emphasis on the necessity of proper alignment of the crankshaft. The setting of the several valves was discussed, also the desirability of having the valves in good condition. Air-compressor behavior was, so the speaker felt, one of the most important things in operating procedure. The use of excessive amounts of lubricating oil, leaky valves and poor cooling were the basic causes of a occasional air-compressor failure. It was the opinion of the author that the Diesel engine was one solution of the problem of ways and means of reducing the cost of power. For this reason engineers should investigate the Diesel with open-mindedness, for while it was not the proper prime mover for all plants, there were thousands of factories where it was the logical machine to install.

Refrigerating Plant Design

In a paper on The Development in Refrigerating Plant Design, Halbert P. Hill briefly outlined the origin of the compression and absorption systems. Special stress was laid on the increasing use of the high-speed compressor made possible by the electric motor drive. The speaker outlined the advantages of the compound compressor together with those of the electric and oil-engine drive.

The improvements in condenser design have been marked. Originally, the atmospheric was used exclusively, but recently the shell-and-tube type has been installed in several plants, while many other designs are in use.

There is probably no process that has been as slow in development as raw-water ice manufacturing. The quality of the water has a material bearing on the clearness of the ice. With good water the ordinary drop-pipe low-pressure air system can produce clear marketable ice. The main disadvantages are the sucking of the cores and the removal of the air tube, both of which are labor problems. With high-pressure systems the air is kept on until a can is completely frozen. For this reason it makes a better ice with inferior water. Most all of the high-pressure systems are alike in principle, and the main difficulty lies in drying the air. With the well-designed dehumidifying system a large part of this trouble is eliminated.

Few freezing tanks have sufficient agitation, and very few are properly piped, since one must have sufficient cooling surface for the brine coolers. It has been found that 30 sq.ft. of cooler surface per ton of ice is none too much, and there are many plants installed having as low as 18 ft. Where coils are employed, they should be connected up so that the freezing tank can be operated flooded. This cannot be done unless means are provided to prevent slopping over and freezing back to the machine.

The introduction of accumulators set in the freezing tanks in a manner accomplished this purpose, but the modern method is to place the accumulator at a convenient point below the freezing tank. It is piped up with the cooling coils, and an ammonia pump is installed, so that any liquid that slops

over into the accumulator can be taken off by the pump and delivered to the high-pressure side of the system. The complete paper will appear in a future issue.

Electrically Operated Steam-Flow Meters

In a paper, "Electrically Operated Steam-Flow Meters," J. M. Spitzglass, vice-president of the Republic Flow-Meters Co., told of the development of the Republic electric steam-flow meters and called attention to conditions that must be observed in the installation of these meters. For obtaining a differential pressure due to flow for operation of the meters the speaker made special reference to the pitot tube and the orifice plate and said that "In general the pitot tube has the advantage of being easily inserted into the pipe line through a convenient standard tapped opening. It has some disadvantages as compared with an orifice plate, which is the differential medium chiefly employed in present installations. The main disadvantage of the pitot tube lies in the fact that the measurement is obtained at a single point in the section of the pipe. If this section follows a straight length of pipe in the line, the 'point' measurement may represent accurately the average velocity in the pipe. If, however, the section follows a fitting or any turn in the line, the 'point' measurement will not represent the average velocity, and the readings will not be correct. The pitot tube, therefore, is used for practical purposes with this restriction in mind.

"Another disadvantage of the pitot tube is that its use is limited to a definite range of capacity for any given meter. For instance, a pitot tube may be used advantageously if the velocity of the fluid in the pipe will be of a magnitude that will raise a measurable column of mercury for operating the flow meter. If the velocity is low, the column of mercury raised will be insignificant for measurement. In other cases the velocity pressure may be too high for the range of the measuring device. When medium velocities are obtained, the pitot tube can be used conveniently, but its accuracy always depends upon whether or not the point measurement actually represents the average velocity in the pipe.

"In the practical application of the orifice plate differentiation should be made between the close tap with the opening at the smallest area of the jet and the far tap at the section of uniform flow on the low-pressure side of the orifice. It is recommended that the close tap should be used in all cases where the differential pressure does not exceed the maximum head of the meter body. When this opening is used for the low-pressure side, the maximum drop of pressure through the orifice is available as the effective head in the meter body. There are cases where the far tap is utilized to great advantage. If the flow has an original high velocity through the pipe, any restriction will bring about an excessive drop through the orifice. In such cases the restoration of pressure is quite significant and the use of the far tap will bring the differential within the range of the meter body.

"Careful consideration should be given to the placing of the orifice in the pipe so that the flow will approach the opening in straight and parallel lines. The condition of the piping, before and after the orifice, has a marked effect on the accuracy of measurement. Bends in the pipe, tees, obstructions—in fact, anything that will produce an uneven or a swirling motion—introduces an unknown factor in the accuracy of the measurement.

"It is not always possible to obtain ideal conditions for the location of an orifice plate. It must be clearly understood, however, just what deviation from the standard may be allowed and what the effect will be on the accuracy of the measurement. In general, it may be said that the necessity of adhering to standard conditions depends upon the ratio of the orifice to the pipe area. When this ratio is small, a slight disturbance in the pipe seems to have a relatively small effect on the accuracy of the measurement. On this account it is often possible to place a small ratio orifice under most unsatisfactory conditions of piping, where the medium or large ratio orifice would not operate satisfactorily.

"Long-radius bends and expansion loops may be considered the nearest approach to a straight length of pipe. The effect of the centrifugal force is minimized by placing the pressure tap at right angles to the plane of the bend. In general, wherever the orifice is close to a given fitting, the pressure taps should be made as close to the flange as possible."

Meters in the Boiler Room

E. C. Bailey, president, Bailey Meter Co., gave an interesting illustrated lecture describing the application of boiler-room instruments and the selection of indicating and recording meters to give all data necessary for least expenditure. The speaker used lantern slides to show present trends in power-plant design and by the use of heat-balance diagrams called attention to the improvement in power-plant economy made in the last few years, by using combustion control for the proper proportioning of the air and fuel fed into the boiler and by making intelligent use of the data obtained from instruments.

A More Comprehensive Educational Program

Thomas G. Thurston, editor of the *National Engineer*, gave a snappy review of the past performance of the Association, analyzed the present unsatisfactory conditions and outlined a constructive and comprehensive service program for the future, which if followed, will bring prestige to the society and make it an authority on power-plant operation.

Apparently, information was what the membership wanted, rather than education, and he proposed to give it in a loose-leaf binder containing a summary of all kinds of operating data and information collected and compiled by the various local associations under the direction of the Education Committee, including a selection of questions and answers that had appeared in the *National Engineer*. The lectures and slides should be brought up to date and supplemented, and if a regular educational program was desired, a definite relationship should be established with the leading educational institutions of the country devoted to engineering. As a means to the end it was proposed that the per capita tax be increased to $2. With a real service program the membership could be increased to 50,000, making an increase in advertising rates and patronage feasible so that an income of $100,000 to $150,000 per year would be conservative. The service that might be rendered the operating engineer by the annual expenditure of such a sum would be tremendous.

Power-Plant Cost Committee

The report of the Power-Plant Cost Committee was presented by its chairman, Egbert Douglas, who referred to the lamentable absence of operating cost data in thousands of isolated power plants. The only figures kept in many of these plants are the cost of the coal, labor and miscellaneous supplies. Often such records as do exist are not available to the operating engineer. Even where electric meters are installed and costs kept, the error is frequently made of computing all costs on a basis of kilowatt-hour output.

In this connection the committee pointed out the necessity of segregating the costs into two parts—first, the steam-generation costs, and second, the power-generation costs. The former should include all expenses connected with the boiler room, such as labor, fuel, maintenance and supplies and should be reduced to the cost per 1,000 lb. of steam produced. The latter should cover all engine-room charges, including the cost of steam actually used for power production, and should be reduced to a kilowatt-hour basis.

It was suggested that the N.A.S.E. had the opportunity through its membership and subordinate associations to accumulate an immense amount of cost data for plants of all classes and sizes, which information could be analyzed by the committee and a simple system of records evolved for plants of various classes that would meet the needs of the membership in their particular industry.

An appendix to the report contained the operating costs of the plant at the Milwaukee Public Museum, which, although 25 years old and having no uses for exhaust steam other than heating, has successfully held out against the central station and actually shows a saving of thirteen thousand dollars a year over comparative figures based on purchased power and steam for heating.

Report of Technical Papers Committee

The excellent work of this committee was reflected in the character and number of technical papers appearing on this year's program, setting a precedent that it is hoped will receive the hearty endorsement of the membership and be followed in succeeding conventions.

Appreciative of the importance and prestige that has attended the work of the Prime Movers Committee of the N.E.L.A. during the last few years,—a work devoted almost entirely to large plant equipment, however—the Technical Papers Committee sees an oppor-

tunity for the N.A.S.E. to work along somewhat parallel lines with reference to equipment going into the small plant and thus fill the gap as concerns the needs of the operator of isolated plants. Suggestions were offered as to how such a committee might most conveniently function within the limitations of the financial support available. The recommendations were taken under consideration.

Dudley G. Kimball

National Education Committee

The National Education Committee reported 145 members as having entered the questions and answers contest during the year, for which the first prize of $400 went to Massachusetts Association No. 1, with a percentage of 96.93; the second prize of $250 to H. H. Baumgartner, with a percentage of 96.45; third prize of $125 to John L. Bernier, with 95.8 per cent; fourth prize of $75 to Charles Dick, with 95.02 per cent; and fifth prize of $50 to W. E. Dixon, with 95.01 per cent. Additional prizes totaling $105 were awarded for the best articles submitted to the *National Engineer*. The committee reported further that it had entered into an agreement with the International Correspondence Schools whereby any member might secure a course of study at a special discount.

During the convention much time was devoted to discussing education. Three different plans were proposed: One favored a more comprehensive program under the direction of a central body, such as an educational committee; a second plan suggested decentralized education to meet the needs of the community in which the engineer resides under local directors; and a third plan put forward was for the compiling of useful operating data and information in loose-leaf form ready to be sent out on request. The merit system has been established in Michigan with its five educational courses, for which certificates are issued upon completion by a member, who also receives favorable mention in the Association.

While all agreed that more activity in educational work was desirable and that additional funds should be made available for these purposes by an increase in the per capita tax, no definite decision was reached. A proposed increase in the per capita tax from seventy cents to $2 and later amended to $1 was defeated.

Membership Extension Committee

The Membership Extension Committee, J. A. Wickert, Chairman, presented a commendable report outlining the organization necessary, the functions of the department and the results from a questionnaire calling for constructive criticism of present methods. The response was not gratifying, nevertheless certain suggestions were received and the committee summarized their considerations in thirteen recommendations that should aid in solving the many perplexing problems confronting the association. To provide funds for an active campaign, it was proposed that the national per capita tax should be increased to $2 per year per member and that $2,000 should be appropriated for membership extension propaganda and a general publicity campaign.

A unique and pleasing feature of the convention was the presentation by President Holbrook of appropriate remembrances to all who had rendered commendable service during the year, including his special deputies, and to each and every delegate a steel engraving of James Watt, the founder of steam engineering, accompanied by a likeness of the retiring president.

Garrett Burgess

The budget of $20,405, recommended by the Ways and Means Committee, was approved. Among the more important appropriations were $2,500 to the National Educational Committee, $1,000 to the Membership Extension Committee, $500 to the engineer's license committee, $500 to the Power-Plant Cost Committee, and the usual $100 to the ladies' auxiliary. Mileage voted at 7 cents per mile amounted to $17,518.76 and, added to the appropriations, gave a total of $37,923.76. Income from the *National Engineer* was given as $25,668. The contract for printing the paper for the term of five years was renewed with Mechanical Press.

The Lane memorial fund for establishing scholarships was voted down.

J. D. Taylor reported that the Life and Accident Department, although suffering a decrease in membership during the year, was in excellent financial condition, the disbursements amounting to a little over $4,000 and the reserve on hand over $12,000, including cash and government bonds. In order to stimulate a drive for increased membership in this department, he suggested prizes to the collectors who will present the largest number of bona fide members during the next year.

The social features of the program included an informal reception at the Hotel Pantlind on Monday night, a barbecue and boat ride on Wednesday afternoon, which 1,800 attended, followed by an entertainment through the courtesy of the National Exhibitors Association in the evening and a ball at the Pantlind on Friday night.

St. Paul, Minn., was selected as the next convention city.

National N.A.S.E. officers elected for the ensuing year are: Dudley G. Kimball, president; Garrett Burgess, vice-president on the first ballot; Fred W. Raven, secretary; Samuel B. Forse, treasurer; Henry J. Mistele, trustee for five years; James S. Heath, national conductor; C. A. Dobson, doorkeeper.

New officers elected for the National Exhibitors' Association are: W. P. Lyons, president; Charles F. Green, vice-president; George R. Rowland, treasurer; F. N. Chapman, secretary.

Water Power Development in the Irish Free State

The question of the development of the Irish Free State's water-power resources has been to the fore in the last three months. The government's agreement with the Siemens Schuckertwerke, of Berlin, for a survey of the possibilities of the River Shannon resulted, it is reported, in a thoroughgoing investigation by the German firm of the resources of the Shannon, and it is expected that the report will be laid before the Dail in the near future. Preliminary information indicates that the river was found to be capable of development that would supply from three to four times the present power requirements of the Free State at a cost of approximately $25,500,000.

Early in the quarter two companies submitted private bills to the Private Bill Office looking toward the hydroelectric development of the Liffey River. Each of the proposed schemes involved the ultimate expenditure of about $6,000,000 and contemplated the generation of sufficient power to supply the lighting and transit requirements of Dublin, according to the Department of Commerce.

Ira, New York, can boast the smallest electric generating station, with the smallest constituency served thereby, of which there is any record. The total consumers of electric current comprise a store, a home, a barn, an office building, two garages, the post office and four street lamps says the *N. E. L. A. Bulletin.*

Application of Power to Paper Making in the United States*

By A. H. White†

IN THE United States the paper and wood-pulp industry ranks fourth in amount of installed power capacity, but as it is a twenty-four hour industry it ranks second in power consumed. Interesting data in regard to the first four industries are given in the accompanying table:

Evidently the paper and wood-pulp industry is a highly important factor as a power user, and power is a highly important factor in the industry.

In the year 1919, 6,098,530 tons (2,000 lb.) of paper was made in the United States. The amount of power used per ton depends upon the sort of paper made. Papers made from wood predominate in the United States, and such require larger amounts of power. Newsprint, consisting of 75 per cent ground wood and 25 per cent sulphite pulp, requires about 1,740 hp.-hr. per ton.

In 1919 news print was 24 per cent of the total production of paper. The 75 per cent of ground wood which it contains is a determining factor in the location of the mill. Ground wood is produced almost exclusively by water power, and as it can be stored over long periods it is the custom to overdevelop ground-wood mills, thus making use of much more than the low-water flow of the streams.

Again, as paper making requires much water, it is natural that paper mills are ordinarily built adjacent to water courses. This fits in nicely with the use of water power. The great majority of paper mills are run by water power, either directly or by electricity generated by water power. In the old days many paper machines, as well as the machines for preparing and handling stock, were run directly by waterwheels.

When steam for drying paper came into use, it was soon found that the steam engine would give much better regulation of the paper machine, and at the same time reduce the steam pressure to a point suitable for drying purposes. Since the driving of a paper machine requires only 3 to 5 per cent of the heat units in the steam, and as in most cases some live steam is required to supplement the exhaust, the efficiency of the steam engine driving the paper machine has not been of interest to the paper maker.

For many years the paper maker, and others for that matter, did not realize the importance of efficiency in water turbines. Twenty-five years ago the paper maker was content with waterwheels giving 80 per cent efficiency. Today we ask for and get from 88 to 92 per cent.

In a well-balanced newsprint mill about 15,000 lb. of steam is required per ton of paper. Steam is used in cooking and treating the stock, drying the paper and heating the buildings.

In recent years the paper maker in the United States has awakened to the importance of economy and efficiency in the steam-generating plant. Boilers of the efficient and safe type are generally used, as well as stokers, economizers and such auxiliaries and instruments as make for economy.

Probably the greatest and most radical change in the application of power in paper making has been the introduction of electrical transmission. In 1919 about 30 per cent of the power used in paper making in the United States was transmitted electrically. One large mill is driven entirely by electricity, the power being generated some twenty miles away. The adoption of electricity for the transmission of power at this plant permitted the erection of the mill at the most favorable point with regard to shipping facilities, the receipt of raw material and the labor market.

Some fifteen or sixteen years ago an attempt was made to drive paper machines electrically. The method finally adopted involves the use of direct-current motors whose speed is compensated by small synchronous motors as the load varies.

Since only from 3 to 5 per cent of the heat units in the steam are needed for driving the machine, the other 95 to 97 per cent are available for drying the paper. Therefore, in an electrically driven machine it is economy to generate electricity by steam, using the exhaust from the turbine or engine for drying. Some mills use water power generated electricity for driving the machine, and live steam for drying. At any reasonable cost of hydro-electric power this cannot be economical, nor are there any advantages to be gained.

Another advance in the application of power in paper making has been made in Scandinavia and is starting in the United States. This is the generation of steam at relatively high pressures, reducing the pressure through steam turbines for power purposes, and using the exhaust for cooking stock and drying paper.

This practice, possible when large amounts of heat are required other than for power and relatively small amounts of heat for power, will result in a low combined cost.

*Abstract of paper delivered at the recent World Power Conference.

†Chief engineer, International Paper Co.

POWER, CAPITAL AND LABOR IN FOUR INDUSTRIES

	Primary Horsepower Installed	Capital Invested per $1,000,000 Horsepower $000 Omitted	Horsepower Invested Capital	Total Number of Employees	Horsepower per Employee
All U. S. industries	29,507,000	44,569,594	662	9,096,000	3.2
Iron and steel, including blast furnaces and rolling mills	5,402,000	3,458,935	1,562	416,759	13.0
Lumber and timber products	2,359,000	1,357,992	1,730	480,950	4.9
Cotton and wool textiles	2,330,000	2,735,958	852	437,460	5.4
Paper and wood pulp	1,851,000	905,795	2,043	113,760	16.3

Power-Plant Proprietor's Legal Responsibility

By Arthur L. H. Street

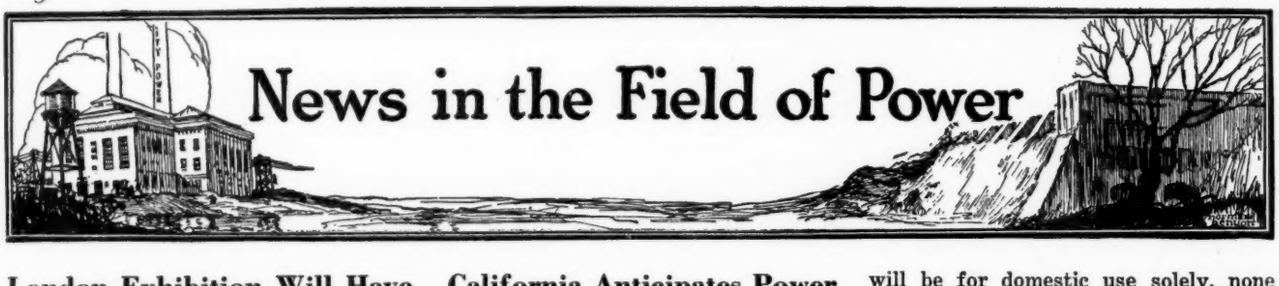
The decision lately handed down by the Oklahoma Supreme Court in the case of Kaw Boiler Works vs. Frymyer, 227 Pacific Reporter, 453, affords a clear and concise view of some fundamental rules of law applicable to instances in which persons other than employees of the operator of a power plant are injured while a contractor is working on the premises, as where boilers are being installed in a power house. The decision warrants this statement.

The owner of a power plant is liable to third persons for injuries resulting from the doing of the work which are the natural and probable consequences of the usual methods of performing such work. That is, if the owner adopts an inherently faulty plan, he is liable for injuries resulting to third persons as a natural consequence, although such persons may not be his employees, but those of an independent contractor engaged to do the work. A concrete example may be supposed in a case where the owner should contract to have installed in his power plant a boiler plainly too weak to sustain the steam pressure to which it would be subjected in testing it.

But the employer is not answerable for injuries resulting to third persons in the course of the work, through negligence of the contractor. This rule rests upon the principle that the owner is entitled to assume that the contractor will discharge his legal duties to third persons. The rule is illustrated by a case where injury results to an employee of a contractor engaged to install a boiler, or to some third person, not through inherent defect in the boiler plan, but through negligence in the manual labor of setting it up.

Owing to the friable nature of most of the coal mined in Great Britain, according to *The Engineer*, there is a large percentage of dust, which has so far been utilized in the manufacture of briquets. The making of briquets has therefore become a very important industry. It appears likely that briquet firms will have to pay much more for their coal dust or will be obliged to make a larger use of peat and other substitutes now that there is a growing demand for small coal for raising steam with pulverized fuel. Many of the steam-raising plants now being laid down are equipped to use pulverized coal, and the system appears to be making steady headway on account partly of the lower cost of the small coal, the stocks of which at the collieries are considerable.

The Alberta government has received a request from the firm of Vickers, Ltd., London, England, for samples of high-volatile lignites and bituminous sands for test purposes. This company has expended considerable capital in perfecting systems for the manufacture of coal byproducts and has just completed a process for low temperature distillation of coals and oil shales.



London Exhibition Will Have American Section

There will be an American section at the 1925 Shipping, Engineering and Machinery Exhibition in London. Sir Charles Parsons is the president of the organization, which conducts such an exhibition biennially. F. W. Bridges, the general manager of the show, will visit the United States in October to confer with the American manufacturers who may be interested in participating in next year's exhibition.

Hydro-Electric Development in Latvia

The Latvian Government has for some time been studying the possibilities of developing hydro-electric power on the Dwina River, on which the City of Riga is situated, and a certain amount of information has been developed. The needs of the industries of Riga have given impetus to the possibilities of using various high heads in the river for generating electric energy, according to *Commerce Reports*.

The project is being studied at present by German and Swiss interests which would probably combine with the local government and the City of Riga to form a mixed company.

Estimates on the project vary from $2,500,000 to $7,500,000, depending upon the extent of the development. General details of this hydro-electric project are available for loan from the Electrical Equipment Division, Bureau of Foreign and Domestic Commerce, Washington, D. C.

Motor Buried for Eight Years Runs

After being buried underground for about eight years, a motor in California was recently dug up and with a little overhauling was found to be in excellent condition.

A General Electric, Sprague type S, 6-pole 40-hp. 2,200 volt vertical motor was installed in a well on a ranch at Corona, California. In 1916 the well caved in and buried the motor. Recently, the motor was removed from the well, was cleaned up, thoroughly dried, and tested with 4,400 volts to ground and the insulation found to be good. External leads were replaced, some end connections insulated and the windings varnished and baked. The oil piping to the lower bearing had rusted out and was replaced. The two babbitt bearings were in good condition, but the upper ball bearing, being badly rusted, had to be replaced.

The motor was repainted and is now in first-class condition, ready for further operation.

California Anticipates Power From Colorado River

Southern California cities, according to press reports, have redoubled their activities in anticipation of the proposed harnessing of the Colorado River at Boulder Canyon. A large part of the enthusiasm with which this work is going forward is traceable to the recent election held in Los Angeles, the results of which are declared a signal victory for public ownership and the development of the Colorado's resources. Another reason is the unusual drought and consequent lack of power which prevails on the Coast this year. The Colorado River is reported dry from tidewater to Yuma, a port of entry, and upstream to the mining towns of pioneer days.

Activities have been started recently toward a $24,000,000 improvement of the Los Angeles municipally owned electric system in preparation for power from the Colorado River, it is said.

Confidence that Congress will pass the Swing-Johnson bill and thus make possible a maximum development of the entire Pacific Southwest, as well as giving southern California its greatest needs, cheap water and power, is expressed by officials of Los Angeles. Arizona's refusal to ratify the Colorado compact is conceded as a stumbling block to the early passage of the bill, it is admitted. Early elections in Arizona, however, with change of officials may change Arizona's attitude.

The working out of a central plan for bringing Colorado River water to southern California cities for domestic use will receive much impetus, it is expected, from a conference of officials of southern California cities which has been called to meet in Pasadena on Sept. 17. The call to this meeting was issued by Hiram W. Wadsworth, chairman of the Pasadena board of city directors and head of an organization committee authorized by the Boulder Dam Association at its annual meeting in Long Beach on June 15. This committee is at present perfecting a larger body which will undertake to make a thorough study of all laws pertaining to water rights which would be involved in obtaining domestic water from the Colorado and report needed changes so that these may be made by the legislature and the municipalities involved.

Los Angeles, through its department of public service, has already received favorable replies from a large number of neighboring cities, stating their willingness to co-operate in a central aqueduct system to be built at joint expense, which will bring water from Colorado to the Coast. It has been especially emphasized that this water will be for domestic use solely, none of it being diverted for irrigation purposes.

Big Plants Predicted for Coosawattee Sites

Three big power plants are in prospect along the Coosawattee River as the result of a settlement of long litigation between the N. P. Pratt interests and the Washington Land Co., said to be controlled by the Georgia Railway & Power Co. According to the terms of the settlement, which was made out of court, the Pratt interests will now have undisputed title to lands for about 15 miles along the Coosawattee River, while the Georgia Railway & Power Co. will take possession of seven miles on the river just below this. Mr. Pratt, it is said, contemplates the construction of one power plant, while the Georgia Railway & Power Co. is expected to construct two. If the Coosawattee developments are made in accordance with predictions, they will involve a total cost of $18,000,000 and provide for the eventual development of 120,000 hp., to be distributed over a wide area in north Georgia.

Aims of A.A.E. Outlined to President

President Coolidge received on Sept. 4 a delegation representing the American Association of Engineers, who called to pledge the support of the organization in connection with any effort of the government to improve engineering conditions throughout the country. The delegation was composed of Harold Almert, of Chicago, the president of the organization; A. N. Johnson, P. H. Newell, Morris Bien and A. B. McDaniel.

They told the President that their association has a membership of 16,000, with chapters in every important center of the population, devoting their energies to the welfare of professional engineers. They explained that the American Association of Engineers differs from the more technical engineering societies, in that its first consideration is of the human element. Mr. Coolidge was told that the basic purpose of the association is to make the engineer a broader and more efficient man and to arouse his active interest in public service. They called his attention also to the fact that the association at this time is initiating a national program dealing with fuel conservation, railroad valuation, the proposed department of public works and the classification and compensation of engineers.

Southern Exposition To Be Held in New York City

The Southern Exposition will be held at the Grand Central Palace, New York City, Jan. 19-31, 1925. The exposition is planned to show to the world what the South has done and is accomplishing. Exhibits will include products of factories, industries, mines, agriculture and horticulture; the means and equipment for transportation, power, sanitation and education. Pictures and specimens of natural resources will also be featured.

Utility Courses Started at Temple University

The utility courses to be given at Temple University during the coming winter, under the auspices of the Pennsylvania Public Service Information Committee, cover the technical phases of the central stations, power plants, manufactured gas, electric railways and telephone utilities as well as a comprehensive course dealing with the general business and economics common to all utilities. These courses will all be given in lecture form by competent operators and executives.

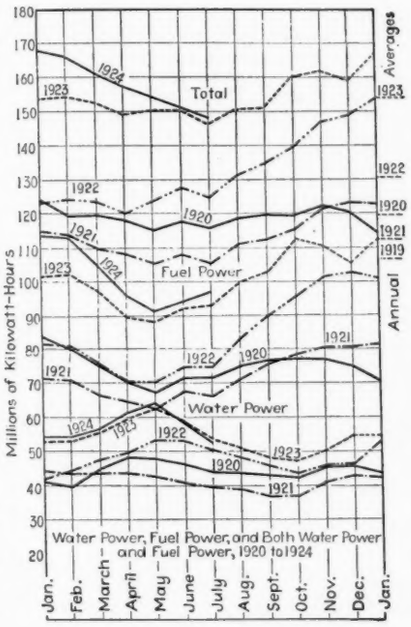
Courses in central station engineering cover: Generating stations operated by steam, water, mercury turbine, internal-combustion engines, etc.; heat balance; fuel supply and handling; boiler plants; electrical equipment; substations; interconnections; and operating methods will be given by F. C. Ralston; transmission will be taken care of by H. S. Phelps; distribution by P. H. Chase; meters and metering by J. B. Straw and R. I. Hart; operation of system, load dispatcher and trouble dispatcher by Robert Black and C. D. Buchholz.

The outline of the general course and lecturers is:

"General Talk," P. H. Gadsden, vice-president, The United Gas Improvement Co.; "General Business Economics," J. O. Keller, Prof. Industrial Engineering, Pennsylvania State College; "Public Utilities and Privately Owned Business Undertakings," M. H. Aylesworth, managing director, N. E. L.A.; "Duties of Public Utilities; Rights of Public Utilities," J. T. Hutchings, vice-president, the United Gas Improvement Co.; "Regulation by Public Service Commissions," Alex. Forward, secretary-manager American Gas Association; "The Corporate Organization of a Public Utility," L. R. Dutton, manager, Philadelphia Suburban Gas & Elec. Co.; "Analysis of Balance Sheet and Income Statement," J. E. Zimmerman, Day & Zimmerman, Inc., engineers; "The Financing of Public Utilities," W. W. Bodine, assistant to gen. mgr., the United Gas Improvement Co.; "Methods of Obtaining Value," "Valuations and Appraisals," "Rate of Return," C. J. Joyce, counsel, Philadelphia Rapid Transit Co.; "Rate System," C. J. Russell, vice-president, the Philadelphia Electric Co.; "The Uses to Which Revenue is Put," W. H. Johnson, president, the Philadelphia Electric Co.; "Publicity and Public Relations," P. C. Staples, vice-president, The Bell Telephone Co. of Penna.; "Importance of Employees in Development of Public Utilities," A. A. Mitten, supervisor of industrial relations, Philadelphia Rapid Transit Co.

Production of Electricity by Public Utilities in July

The average daily production of electricity by public-utility power plants based on the operation of about 4,000 power plants, each producing 10,000 kw.-hr. or more per month, engaged in generating electricity for public use, including central stations, electric railway plants, and certain other plants that contribute to the public supply in July was 148,300,000 kw.-hr., about 2 per cent less than the revised figures for the daily output of the month of June according to the Geological Survey. The curve of average daily total output for 1924 shown indicates that the average daily output of electricity by public-utility power plants has decreased uniformly each month from April to July. Since there was no increase in the rate of decrease in July, it probably can be stated, based on previous records, that the rate of decrease in the demand for electricity which has continued so uniformly so far this year probably reached a minimum in July and that the figures of output for August will probably show an increase.



Power Curve Descends

The average daily production of electricity by public-utility power plants and the proportion produced by water power for each month of this year were as follows: January, 167,400,000 kw.-hr.—32.3 per cent; February, 166,700,000 kw.-hr.—32.3 per cent; March, 160,800,000 kw.-hr.—34.4 per cent; April, 158,000,000 kw.-hr.—39.2 per cent; May, 154,600,000 kw.-hr.—40.7 per cent; June, 151,800,000 kw.-hr.—37.5 per cent; July, 148,300,000 kw.-hr.—35.1 per cent.

Pan-American Standardization Conference in December

The First Pan-American Standardization Conference is to be held in Lima, Peru, in December. This conference called with the co-operation of all the American republics, will determine upon uniform specifications and quantity, nomenclature for raw materials, merchandise and commercial equipment. An important section of the conference will deal with the standardization of containers, packages and packing. The need for uniform containers will be stressed. The session will also take up the general subject of standardization, its principles and its importance in the economic development of the world with particular reference to inter-American trade.

Power Commission Target for Criticism

An attack on the Federal Power Commission is about to be launched by the advocates of public ownership of utilities. The movement has its principal support in California, where it is contended that the Commission is entirely hostile to public ownership and has nullified the priorities granted in the act to municipalities.

It is contended further that the attitude of the Federal Power Commission, revealed at the hearings on the Swing-Johnson bill, is that the whole conception of the Boulder Canyon dam on the Colorado River is an experiment in public ownership. From what is known of the attitude of the Commission it is thought the foregoing assumption is correct. It is known that the Commission has learned that it is the ambition of certain individuals to build up in California a hydro commission like that in Ontario.

If California thinks it can find the Sir Adam Beck and is willing to undertake a development on the Colorado, which will fit into a general plan for the utilization of the full resources of the stream, and would be willing to finance its experiment itself, it is regarded as entirely probable that the Federal Power Commission would be willing to grant the necessary license and assist in every way to make the development a success. It is very evident, however, that the financing out of the Federal Treasury of developments within states conflicts with the policy of the Commission. It also is very evident that the Commission believes that private development of power is more likely to be successful than are municipal or state schemes, due to the fact that extensions, rates and policies would be subject to political control which frequently deviates from the path that would be chosen by private enterprise.

It is believed that the three secretaries making up the Commission would hold similar views with regard to any excursion of the public into business. There is every reason to think, however, that they would be perfectly willing to aid any municipal or state project were the public agency to be ready to finance its own project.

Paris Generating Stations To Be Enlarged

The total power of generating stations in the Paris district increased from 95,000 kw. in 1919 to 200,000 kw. in 1923, according to the chief engineer of the Paris lighting service. The two generating stations providing electricity for this district are being enlarged; the St. Ouen plant, which produced 80,000 kw. in 1920, will have a capacity of 340,000 kw. by 1926, while the Issy-les-Molineaux will be increased from 30,000 kw. to 110,000 kw. during the same period of time.

It is anticipated that even this supply will be insufficient to meet future demands, and as land in the neighborhood of Paris is expensive and difficult to secure, the transmission of electricity from hydro-electric stations in the mountainous regions of France will be attempted.—*Commerce Reports.*

St. Lawrence River Project Delayed

Plans of the Hydro-Electric Commission of Ontario for an extensive power development on the St. Lawrence at Morrisburg are being held up by reason of the application to the advisory committee which is dealing with the original deep waterways, power and navigation project of the St. Lawrence, according to press reports.

This committee, an inter-departmental committee of engineers, takes the position that the privilege sought is exceptional on account of its international aspect, and, therefore, it should go to the commission comprised of members of both countries which is inquiring into the whole question of St. Lawrence development.

The general project is also being delayed at present because the United States government wishes to enlarge the scope of the inquiry.

Next Power Conference May Be in United States

Hydro-electric development throughout the world is certain to be stimulated by the World Power Conference, in the opinion of O. C. Merrill, executive secretary of the Federal Power Commission and general chairman of the American Committee of the World Power Conference. "Delegates from forty nations attended the conference who will return to their countries," said Mr. Merrill, "with a new realization of the potentialities of their water-power resources. They now have precise information as to what other countries are doing and have a more accurate idea as to the feasibility of developments in view of what they have learned as to the experience in other countries.

"The probabilities are that similar conferences will be held periodically at intervals of from three to five years. The opinion of many at London seemed to be that the next conference should be held in the United States, but Italy is prepared to contend vigorously for it."

Bearing Metals Research Needs $50,000

The A.S.M.E. Special Research Committee on Ball Bearing Metals are out to raise a fund of $50,000 to obtain a specialist for five years who will energetically prosecute research in this field either at the Bureau of Standards in Washington or another laboratory where conditions are favorable.

The scope of the research being undertaken by this committee is so far reaching that there is no industry in the country which would not be benefited by it. Previous to this, practically all the studies and tests on bearing metals which have been undertaken in the various laboratories have been made by mechanical engineers who have given scant attention to the chemical composition of the metal. Another striking shortcoming is that the bearing only has been considered; the journal has been neglected. For satisfactory service conditions the journal and hearing must polish each other. This fact had never been taken into consideration until the A.S.M.E. Committee undertook this work. They developed an instrument by which the abrasive hardness of the various alloys can be determined in a practical way. The study of microhardness of different alloys in this research is important and is being taken up by the American Society for Testing Materials.

Further research in the whole field of bearing metals is so vital to all users of bearings and manufacturers of bearing materials that successful financing of the project is confidently anticipated.

The Committee composed of C. H. Bierbaum, chairman, John A. Capp and Prof. H. Diederichs, has not only secured subscriptions amounting to $13,000 but they have received assurance from industries everywhere that they are in hearty sympathy with the project. The interest of the Engineering Foundation, which is acting as trustee for the fund, is evidenced by a subscription for $5,000.

Trade Statistic Decision Awaits Election

APPARENTLY, the Department of Justice has placed the entire controversy with regard to trade association statistics in cold storage until after the election. While it is regarded as practically certain that the Department will take no exception to the association, which collects statistics of production and stocks and communicates only aggregates to its members, it is thought certain that no statement with regard to trade associations will be forthcoming at this time.

The strong stand taken by the American Federation of Labor opposing undue limitation of trade-association activities is expected to discourage any demagogic attacks on this type of business activity.

Oregon May Have Public Ownership Bill

A constitutional amendment which would bond the State of Oregon and put it into the business of generating and selling electrical energy may be submitted to the state legislature which will convene early next year. The amendment is said to have been the work of a committee of the Public Ownership League, which was organized about a year ago under the auspices of the Public Ownership League of America. The advocates of the measure state that if the amendment is submitted to the legislature and that body does not introduce it for preliminary consideration, or in any manner changes its provisions, it will be withdrawn and placed on the 1926 general election ballot by initiative petition.

The intent of the bill is declared to be to conserve, develop and control the waters of the state by publicly owned utilities.

Power of Board

A board of five to be elected by the people and to serve without compensation would administer the provisions of the act. The board is given power "to issue and sell bonds, to construct or acquire by purchase, lease or condemnation, gift or other legal means, water, water rights, easements, or electrical energy, and to construct and operate works, dams, reservoirs, power houses, transmission lines, structures, roads, railroads and any other property necessary or convenient for the purpose of the act." It is provided, however, that no plant shall be purchased for a consideration of more than $500,000, until such purchase shall have been approved by a vote of the majority of the legal electors of the state or political subdivision thereof at a general election.

A revolving fund of $5,000,000 is provided, which would be used to defray the expenses of acquisition, construction, and operation and maintenance of projects undertaken by the board. If at any time the revenues from projects are insufficient to pay the interest and principal on outstanding bonds, the board may issue and sell bonds to meet such payments. The board would have full power to establish rates for service which in its judgment would provide for all operating expenses and interest and principal on bonds and retire the investment in a project in fifty years. The state and political subdivisions are given a preferential right to water and electric energy controlled by the board as against privately owned public utilities selling water or electric energy to the public.

In any proceeding in eminent domain brought by the board the determination of the board that the taking of the property described in the complaint is necessary shall be conclusive evidence of such necessity. In any proceeding the state may take immediate possession and use of any property deemed necessary by paying into court such amount of money as the court may determine as reasonably adequate to secure to the owner immediate payment of just compensation for such taking and damage incident thereto.

Society Affairs

The American Society for Steel Treating will hold its annual convention at the Copley-Plaza Hotel and the International Steel Exposition at Commonwealth Pier, Boston, Mass., Sept. 22-26.

The Boston Section of the A.S.M.E. will visit the Worthington Pump & Machinery Corp. plant at 265 Third St., Cambridge, Mass., for the inspection of Diesel engines under construction and running on test on Sept. 18 at 3 p.m.

The American Engineering Council will, through the generosity of James Hartness, its president, have a printed record of the members of the Council. The volume is now in course of preparation and will include those who are delegated to representation on the Council as well as all past members.

The Boston Section of the A.I.E.E. has announced Oct. 18 as a tentative date for the inspection of the new Weymouth station of the Edison Electric Illuminating Co. Following a talk on the interesting and novel developments necessary to control high-pressure steam, there will be a general inspection of the station with possibilities of supper in the generating room.

The American Engineering Standards Committee has recently appointed local representatives of the committee in four important industrial centers. These are: K. F. Treschow, secretary, Engineer's Society of Western Pennsylvania, Pittsburgh; J. B. Babcock, executive secretary, Affiliated Societies of Boston; Edgar S. Nethercut, secretary, Western Society of Engineers, Chicago; Prof. George S. Wilson, Engineering Experiment Station, University of Washington, Seattle.

Personal Mention

L. W. Klein, Pottsville, Pa., has become vice-president of the Green Engineering Co., of East Chicago, Ind.

William M. Bostwick, formerly with the General Electric Co. at Lynn, Mass., has become a mechanical engineer for the Texas Light & Power Co., at Dallas, Tex.

J. H. Sadler, who was superintendent of the Mt. Holly Steam Plant of the Southern Power Co., Mt. Holly, N. C., has become superintendent of the Tiger steam station of the same company at Duncan, S. C.

George S. Norman, formerly with the Tide Water Oil Co., has recently become manager of the lubricating oil department of the Pierce Petroleum Corp., with headquarters at 418 Olive St., St. Louis, Mo.

William R. Kales, former president of the Detroit Engineering Society, has announced his decision to become a candidate for Congress in the First District of Michigan, which includes the east side of Detroit.

Coming Conventions

American Association for the Advancement of Science. Burton E. Livingston, Smithsonian Institution Washington, D. C. Meeting at Washington Dec. 29-Jan. 3, 1925.

American Ceramic Society. Ross C. Purdy, Lord Hall, Ohio State University, Columbus Ohio. Convention at Los Angeles, Calif., Oct. 6-7.

American Electric Railway Association. James W. Welsh, 8 West 40th St., New York City. Meeting at Atlantic City, Oct. 6-10.

American Electrochemical Society. Dr. Colvin G. Fink, Columbia University, New York City. General meeting at Detroit, Mich., Oct. 2-4.

American Institute of Chemical Engineers. Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y. Annual meeting at Hotel Schenley, Pittsburgh, Pa., Dec. 3-6.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Fall convention at Pasadena, Calif., Oct. 13-17.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Autumn meeting at Birmingham, Ala., Oct. 13-15.

American Society of Civil Engineers. 29 West 39th St., New York City. Fall meeting at Detroit, Oct. 23-25.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 1-4.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at New York City, Dec. 1-3.

American Welding Society. Miss M. M. Kelly, 29 West 39th St., New York City. Convention in Cleveland, Oct. 30-31.

Association of Iron & Steel Electrical Engineers, John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Annual meeting and exposition at Duquesne Garden, Pittsburgh, Pa., Sept. 15-20.

Eastern Ice Manufacturers Association. W. H. Ross, 35 Warren St., New York City. Eighteenth annual meeting at Hotel Chelsea, Atlantic City, N. J., Nov. 12-14.

Electric Power Club. S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Fall meeting at Greenbriar, White Sulphur Springs, W. Va., Oct. 20-23.

Empire State Gas and Electric Association. C. H. B. Chapin, Grand Central Terminal Bldg., New York City. Convention at Lake Placid Club, N. Y., Oct. 6-7.

Franklin Institute of Pennsylvania, Centenary Celebration at Philadelphia, Sept. 17-19.

Illuminating Engineering Society. Norman D. MacDonald, 29 West 39th St., New York City. Convention at Briarcliff Lodge, Briarcliff Manor, N. Y., Oct. 27-31.

National Association of Practical Refrigerating Engineers. E. H. Fox, 5707 West Lake St., Chicago, Ill. Convention at New Orleans, La., Nov. 11-14. Exhibits at the Isaac Delgado High School.

National Exposition of Power and Mechanical Engineering. C. F. Roth, Grand Central Palace, New York City. Annual exposition at New York City, Grand Central Palace, Dec. 1-6.

National Safety Council. W. H. Cameron, 168 N. Michigan Ave., Chicago, Ill. Thirteenth Annual Safety Congress at Louisville, Ky., Sept. 29 to Oct. 3.

New England Water-Works Association, Frank T. Gifford, 715 Tremont Temple, Boston, Mass. Annual convention at Powers Hotel, Buffalo, N. Y., Sept. 23-26.

Society of Naval Architects and Marine Engineers. Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at 29 West 39th St., New York City, Nov. 13-14.

Business Notes

The Fafnir Bearing Co., New Britain, Conn., announces that Phillips N. Case, formerly advertising manager, has been succeeded by Stanley Cooper.

The Coatesville Boiler Works announces the removal of its offices to 1607-8 Packard Bldg., 15th and Chestnut Sts., Philadelphia, Pa.

The Homestead Valve Manufacturing Co., Inc., Homestead, Pa., announces the following new agents to handle full lines of its valves: The Hughes Co., Spokane, Wash.; W. A. Case & Sons, Rochester, N. Y.; Smith & Pearson, Auburn, N. Y.; W. H. Kiefaber Co., Dayton, Ohio; Doermann-Roehrer Co., Cincinnati, Ohio; James McGraw Co., Richmond, Va.; Engineering Sales Co., Ashland, Ky.

Trade Catalogs

Belts, Leather—Chas. A. Schieren Co., 30-38 Ferry St., New York City. Leaflets for binder, "Quality Facts About Belting," gives a description of the tanning process in relation to belting.

Meters—Esterline-Angus Co., Indianapolis, Ind. Bulletin 724 describes the graphic meter clocks and kva. meters manufactured by this company. The bulletin is well illustrated and can be had upon request.

Packing, Metallic—The Swain Co., 433 West 37th St., Chicago, Ill. Leaflet describing this packing for high or low pressure, high or low speed, superheated steam and valve-stem packing that rotates with the rod.

Regulators — Defender Automatic Regulator Co., St. Louis, Mo. Catalog No. 19 is the collected bulletins covering the regulating valves and specialties of this company, for automatic combustion control for fuel saving in the boiler room.

Ash Conveyors—The Brady Conveyors Corp., 20 West Jackson Blvd., Chicago, Ill. A new 32-page catalog describing and detailing the operations of Brady steam jet ash conveyors and vitrified glazed tile storage hoppers, with numerous illustrations showing the construction, installation and ash-pit designs, has been issued recently.

Chains and Gears—Stephens-Adamson Manufacturing Co., Aurora, Ill. Section catalog No. 27, 224 pages, is a comprehensive reference book on chains, sprockets and gears, giving the physical data, horsepower and construction, with notes on selection, installation and operation. The material presented has been selected with care and is up-to-date and complete.

Steam Heating—American District Steam Co., manufacturers of "Adsco" heating specialties, North Tonawanda, N. Y. "The History of District Steam Heating," a digest of four talks radiocast from station WMAK, Norton Laboratories, Lockport, N. Y., by George H. West, secretary of the company, is contained in Bulletin No. 177, which can be had for the asking.

New Plant Construction

Ala., Eufaula—The City Council and H. H. Connor, Mayor, will receive bids until Oct. 21, for filter plant of two 500,000-gal. units including 2 centrifugal pumps, 320 and 750 g.p.m. The Ludlow Engineers, Winston-Salem, N. C., are engineers.

Calif., Lockeford—N. H. Locke Co., Inc., plans the irrigation of 335 acres of land. Two centrifugal pumps, 8-in. 3.5 sec.-ft. capacity each against 12-ft. lift to be operated by either electric or gas motors of 25 hp. will be required.

Calif., Lockeford—Mossdale Farm, Inc., will have plans prepared for the irrigation of 300 acres. Centrifugal pumps, 10 ft. operated by gasoline or electric motor of about 40 hp. will be required.

Calif., Los Angeles—The Southern California Edison Co., 306 West 3rd St., has been granted 18 water permits by the State Division of Water Rights, E. Hyatt, Jr., acting chief, Sacramento. The water rights are in San Joaquin watershed above 1,000 ft. altitude, the following developments are planned; 15 reservoirs, 17 power houses to develop about 1,450,000 hp. one 13-mile tunnel, etc. Estimated cost, $200,000,000.

Calif., Modesto—Funds appropriated in budget to finance new pumping unit, estimated to cost, $12,000.

Calif., Oakland—G. Jamieson, c/o M. I. Diggs, 19th and Telegraph Ave., architect, is having plans prepared for the construction of 12-story apartments, estimated to cost $750,000.

Calif., Santa Barbara—The city plans to vote $135,000 for municipal power plant.

Calif., Santa Cruz—City is having plans prepared for a 3,977 hp. power development on San Lorenzo River. H. S. Williams is city engineer.

Calif., Stockton—El Dorado Power Co., subsidiary of Western States Gas and Electric Co., is having plans prepared for a power development on Silver Fork, a tributary to South Fork of American River. The plans include a power plant to develop 24,100 hp. at fall of 848 ft. by impulse wheels or electric generators. Estimated cost will exceed, $3,000,000. Private plans.

Conn., Bridgeport—D. M. Read Co., 1102 Main St., is receiving bids for the construction of a 6-story store building, estimated to cost $1,000,000. J. W. Northrop, Court Exch. Bldg., is architect. Monks & Johnson, 99 Chauncy St., Boston, are engineers.

D. C., Wash.—Dept. of Interior, F. M. Goodwin, Asst. Secy., will receive bids until Sept. 25 for alterations and additions to the power plant at St. Elizabeth's Hospital.

Ill., Chicago—St. Scholastica Academy, 7430 Ridge Blvd. is having plans prepared for the construction of a boiler-house and laundry, estimated to cost, $50,000. Two boilers will be required. E. Buelmaier & Sons, 432 Browy, Milwaukee are architects.

Ill., Pickneyville—The City Clerk will receive bids until Sept. 30 for the construction of a filter plant, pumping equipment, etc., estimated to cost $50,000. A. H. Beard Engr. Co., 616 Title Guaranty & Trust Bldg., St. Louis is engineer.

Ill., Springfield—Meyer Bros., Clothing Co., has awarded the contract for the foundation of a 10 story, 80 x 160 ft. store and office building on Fifth and Washington Sts., A. S. Alschuler, 28 East Jackson Blvd., Chicago is architect.

Ind., Crown Point—The Commings Vote Registering Machine Co., plans the construction of a plant including power house, estimated to cost, $350,000.

Ia., Kingsley—The Town, W. R. Payne, clk., will purchase new pump for water system.

Ia., Ottumwa—St. Joseph's Hospital will soon receive bids for the construction of a 4 story, hospital, boiler house and laundry estimated to cost, $200,000. Boilers etc. will be required. E. Brielmair & Sons, 432 Broadway, Milwaukee are architects.

Kan., Topeka—R. E. Scamell, archt. 422 New England Bldg., will receive bids until Oct. 1, for the construction of a 10-story office building on 10th and Kansas Sts., for the National Reserve Life Ins. Co., 811 Kansas St.

La., New Orleans—The Board of the Presbyterian Hospital, J. C. Barr, Pres., had plans prepared for the construction of a 10 story hospital, including nurse's home and physician's office building, estimated to cost, $1,000,000.

La., New Orleans—The Canal-Baronne Realty Co., E. M. Loeb, pres., had plans prepared for the construction of a 16-story store and office building at Common and Baronne St., estimated to cost $1,500,000. S. S. Joy, Pershing Road, Chicago, is architect.

Mass., Boston—W. M. Evatt, 200 Devonshire St., is having sketches made for a 9-story mercantile building, estimated to cost $1,000,000. A. H. Bowditch, 44 Bromfield St., is architect. Pettinghill Andrews Co., 511 Atlantic Ave., lessees.

Mich., Detroit—United States Mortgage Bond Co., Majestic Bldg., awarded the contract for the construction of a 9 story office building on Congress & Shelby Sts., to Malow Barry Co., 2631 Woodward Ave., estimated to cost $1,000,000. H. Angell, 607 Free Press Bldg., is architect.

Minn., Lakeville—The Village, G. W. Tullock, Clk., is receiving bids until Sept. 24 for improvements to waterworks system including pump, pump house, etc., estimated to cost $22,000. Druar & Milinowski, 500 Globe Bldg., St. Paul are engineers.

Mo., Doniphan—Doniphan Light & Ice Co., c/o S. J. Danner, pres., is receiving bids for two 50- or 70-hp. oil engines direct connected to generators 50 or 55 kw. each, transformers, 10-ton raw water ice plant with 2-ton refrigeration, etc. Private plans.

Mo., St. Joseph—The City Council will submit the following propositions to the voters; whether to expend $292,000 for improving the municipal electric light plant to generate its own current or $115,000 to handle current purchased from the local street car company. One 500-kw. unit, Diesel engine plant and additional 500-kw. Diesel engine for emergency use, etc., will be required, if the city manufactures its own power. C. E. Smith Co., Railway Exch. Bldg., St. Louis, Consult. Engrs., have submitted report prepared by G. H. Packwood, Mech. and Elec. Engr.

N. J., Trenton—Cadwalader Apartments Corp., C. F. Foley, Pres., plans the construction of an 8 story fireproof structure on West State St. and Hermitage Ave.

N. Y., Kingspark—State Hospital Commission, Albany, awarded the contract for the construction of power house to McHarg and Barton, 1328 Broadway, New York.

N. Y., New York—Friedman White Realty Co., c/o C. B. Meyers, 32 Union Sq., Archt. and Engr., will build a 15-story apartment on West End Ave. and 100th St.

N. Y., New York—N. J. Hess, c/o Rouse and Goldstone, 512 Fifth Ave., Archts. are having plans prepared for the construction of an apartment on East 65th St., estimated to cost, $800,000.

N. C., Davidson—Board of Aldermen and C. H. Hamilton, Mayor, will receive bids until Sept. 22nd. for the construction and equipment of water filtration plant, including a raw water pumping station.

N. C. Thomasville—The City, R. M. Cooksey, City Mgr., will receive bids until Oct. 1, for the construction of waterworks improvements to consist of raw water pumping station on Abbotts Creek with pumping and electrical equipment for same, complete water purification works with mixing chamber, subsidence basin, filters and clear water reservoir together with all operating equipment, complete pumping equipment and electrical connections. W. C. Olsen, Raleigh, N. C., is engineer.

N. D., Carrington—The City, C. C. Carnahan, Clk., will receive bids until Sept. 26th, for improvements to water works. Bids for pumping equipment will be taken later. L. P. Wolff, 903 Globe Bldg., St. Paul is engineer.

O., Cleveland—Cleveland Electric Illuminating Co., c/o E. J. Cook, Illuminating Bldg., awarded the contract for superstructure for steam power plant on Lakeside Ave., to Hunkin-Conkey Construction Co., Hunkin-Conkey Bldg.

Okla., Clinton—City voted $80,000 bonds for new water supply, including pumping station, etc., B. M. Hart, City Hall, Oklahoma City, Okla. is engineer.

Okla., Panama—City is having preliminary plans prepared for a new water works system, including motor driven deep well pump, estimted to cost, $25,000.

Ore., Portland—The Steel Tank & Pipe Co., F. W. Small, Gen. Mgr., c/o West Coast Iron & Steel Works, 28th and Nicoli Sts., plans a complete plant including shops, yard, etc., on 15½-acre site. Owner will purchase engines, machinery, etc., excepting boilers.

Pa., Philadelphia — Germantown Dispensary & Hospital awarded the contract for the construction of a power house on Price St., to Ketcham & McQuade, 1029 Brown St., A. H. Brockie, 254 South 15th St., is architect.

Pa., Philadelphia—Penn. Mystic Shrine, W. Kendrick, 1337 Spring Garden St., Archt., is receiving bids for the construction of a hospital including power house and laundry for Crippled Children on Roosevelt Ave., estimated to cost $400,000.

Pa., Philadelphia — Rittenhouse Sq. Phila. Corp., c/o E. D. Thayer, Penfield Bldg., awarded the contract for the construction of an 18-story apartment on S. W. corner of 19th St., to Longacre Engr. Co., 345 Madison Ave., New York, estimated to cost, $900,000.

Tenn., Nashville—The City, H. E. House, Mayor, City Hall, plans election Nov. 4th to vote on $3,000,000 bond issue for the water works improvements, including new boiler plant.

Tex., Crowell—The City has granted a franchise to R. W. Porter, Blackwell, Okla., for the construction of an electric power and ice plant, estimated to cost $100,000.

Tex., Littlefield—R. E. McCaskill, Electra, has been granted a 20-years' franchise to install an electric light and power system, estimated to cost $60,000.

Wis., Bangor—The Village, E. A. Merlo, Clk., plans improvements to water works, including new pumping station. Estimated cost to exceed $15,000.

Wis., Edgerton—L. L. Hannan and E. G. Soltwedel plans the construction of a creamery, estimated to cost, $40,000. Refrigeration machinery will be required.

Wis., Madison—O. Mager & Co., North St., awarded the contract for the construction of a cold storage refrigeration plant to J. H. Findorff Co., 601 W. Wilson St., estimated to cost $100,000. Private plans.

Wis., Manitowoc—Holy Family Hospital, Sisters of Charity, is having plans prepared for the construction of a laundry and boiler house, estimated to cost, $50,000. E. Brielmaier & Sons, 432 Broadway, Milwaukee are architects.

Wis., Manitowoc—The Northern Wisconsin Produce Co., South 6th and Quay Sts., awarded the contract for the construction of a 2 and 3 story, 148 x 150 ft. cold storage plant to Schuette Construction Co., 826 South 8th St., estimated to cost, $65,000. Refrigeration machinery will be required. B. K. Gibson Co., 624 South Michigan Ave., Chicago, are engineers.

Wis., Milwaukee—J. L. Lambrect, 2601 North Ave. is receiving bids for a dairy on 30th St., estimated to cost, $60,000. Refrigeration and special machinery will be required. Herbst and Kuenzli, 130 Grand Ave., are architects.

Wis., Plymouth—Plymouth Refrigerating Co., E. Larsen, Pres., is having plans prepared for the construction of a 10 story, addition to cold storage plant, estimated to cost, $100,000. Refrigeration equipment will be required. E. A. Juul, Security Bank Bldg., Sheboygan, is architect.

Australia, Melbourne—State Electricity, Comm. of Victoria, R. Liddelow, Secy., will receive bids until Nov. 24 for spec. 24/90—22,000-volt cable and accessories and Dec. 1 for spec. 24/88—66,000-volt transformers, induction regulators and accessories for Yallourn Power Scheme. This is part of the Morwell Power Scheme.